The Energy Information Administration's Assessment of Reformulated Gasoline

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Preface

On June 28, 1994, a hearing was held by the U. S. House of Representatives, Committee on Energy and Commerce, Subcommittee on Oversight and Investigations relating to the implementation of the 1990 amendments to the Clean Air Act. As a result of the hearing, the Subcommittee Chairman, Congressman John D. Dingell, sent a letter, dated June 28, 1994, to Ms. Susan Tierney, Assistant Secretary for Policy, Planning and Program Evaluation, of the U.S. Department of Energy. He wrote:

"I request that the Energy Information Administration (EIA) conduct an analysis by October 1994 which examines the final RFG rule, the many guidances, interpretations, etc., the pending rules (if adopted), the ability of the distribution system to handle these matters, including identifying any pipeline and tankage problems, the extent to which smaller refiners will not produce RFG and potentially create supply problems, and all other relevant factors affecting gasoline supplies nationwide, regionally, and by state. The analysis should include expected RFG supply sources beginning December 1, 1994, for each Sub-PAD in PADD I from local refineries, pipelines, barges, and imports...."

This report, prepared in response to the request, is divided into two volumes. The first volume contains EIA's findings and analyses on reformulated gasoline as it affects the petroleum industry. The data contained herein should assist members of the Congress, Federal, State and local governments, analysts, researchers, the media and academia to understand the RFG program and the current status of implementation. The second volume contains 10 appendices that include the letter from Congressman Dingell, survey results, survey forms, and historical summary data. A glossary and a list of acronyms and abbreviations are printed in Volumes 1 and 2.

Recently, two events occurred that impact RFG. The first event occurred September 12, 1994, when the U.S. House of Representatives voted to deny the EPA funds required to enforce its proposed rule to allow foreign refiners to certify RFG using their own 1990 baseline.^{1,2} The Senate had already passed a similar provision. Under these circumstances, the EPA must determine what future course of action will be pursued. Foreign refiners were required to use the statutory baseline in the original final rules on RFG released in December 1993. This event does not affect the RFG supply estimates contained in this report.

Second, the Appeals Court granted a stay of the renewable oxygenate requirement for reformulated gasoline on September 13, 1994. The court will begin hearing oral arguments from all parties on the first available date following the January 12, 1995, filing of Final Briefs. Consequently, the requirement for the use of renewable oxygenates will not be in effect at the January 1, 1995, start-up of the RFG program. The long-term effect is still unresolved. However, the main results presented in the following report pertaining to RFG supply and demand are unaffected by which oxygenate is added to RFG and therefore are unchanged by this event.

¹"Gas Lines, Higher Cost Seen in Tighter Rule on Refined Imported Gas," *Washington Times*, September 14, 1994, B12.

²"House Votes to Deny EPA Funds to Enforce Foreign Rule; Hearing Set on Issue," *The Oil Daily*, September 14, 1994, p. 1.

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Regional Reformulated Gasoline Production and Demand During January 1995 and RFG Demand Areas as of January 1, 1995

(Thousand Barrels per Day)

Sources: Demand areas derived from: "Regulation of Fuels and Fuel Additives; Standards for Reformulated and Conventional Gasoline; Final Rule," Environmental Protection Agency (EPA), December 15, 1993. "Regulation of Fuels and Fuel Additives: Standards for Reformulated and Conventional Gasoline," EPA, June 30, 1994. "Reformulated Gasoline and Anti-Dumping Questions and Answers," EPA July 1, 1994. Pipelines from *Petroleum Storage & Transportation*, vol. 2, the National Petroleum Council, 1989. Production and demand from EIA estimates.

Summary

On January 1, 1995, motorists in designated areas throughout the country will begin using a new, cleaner motor gasoline designed to significantly reduce the pollutants emitted by motor vehicles. Use of the gasoline is mandated by the Clean Air Act Amendments of 1990 and will be implemented through regulations promulgated by the Environmental Protection Agency (EPA). This new product, referred to as reformulated gasoline (RFG), presents challenges to refiners in the form of additional processing steps plus blending components, and to distributors in the form of increased product segregation. RFG is expected to represent a third of the U.S. gasoline market.

Major Findings

EIA estimates that RFG supply will satisfy demand in January 1995:

- **Nationally, during January 1995, RFG supplies are expected to be sufficient to meet the estimated demand level of 2.5 million barrels per day.** Over 97 percent of the RFG production is expected to come from large refiners that have a capacity of over 100 thousand barrels per day (MBD).
- **EIA estimates that sufficient production capacity exists to build primary inventories to just over 20 days of supply, slightly less than observed historical levels but consistent with the introduction of a new product.** In addition, there is enough capacity to build adequate inventories at secondary and retail levels, and to prepare the system to deliver certified RFG to consumers on January 1, 1995.
- **January 1995 RFG demand in PADD I will exceed production by just over 800 MBD while demand in PADD II will exceed supply by a more modest 44 MBD.** PADD III (Gulf Coast) refiners will provide most of the additional RFG required in PADDs I and II with pipeline shipments to those regions.
- **Local shortages of RFG (involving several counties) are a possibility.** Data, in the form of company plans, to determine where shortages are likely to occur are lacking; however, terminals further down the distribution chain from refineries and major pipelines are the most likely sites for shortages.
- **Higher production and distribution costs will create a price premium for RFG, which will be amplified by any imbalance.** EIA estimates production costs for RFG to be 4 to 6 cents higher than those for conventional gasoline, depending upon refinery configurations and oxygenate costs. Additionally, local or regional supply disruptions could result in temporary price run ups. During the introduction of low sulfur diesel fuel, temporary price increases of as much as 30 cents per gallon resulted when localized shortages occurred. The duration of such increases would depend on available resupply, but historically has been less than 30 days.

- **PADD I is exposed to a potential extended shortfall of RFG should it experience a loss of supply of as little as 90 MBD (about 6 percent). PADD V, mainly California, is exposed to a potential shortfall of RFG should any of its refineries experience a problem.**
- **The RFG program reduces the flexibility of the supply and distribution system. Unforeseen events could occur at the outset of the RFG program resulting in dislocations which may be difficult to respond to in a timely manner. Any event, such as severe weather or accidents, would lengthen market adjustment times. Some possibilities are:**
 - Extended and/or severe cold weather that would cause operational problems at refineries, pumps to freeze on pipelines and at refineries, and a sudden increase in the demand for heating fuel would dramatically alter what products must be shipped to distribution terminals. At the highest distillate and kerosene pipeline through put level (observed February 1994), the capacity to transport gasoline is reduced by only 80 MBD (6 percent of maximum historical gasoline/distillate/kerosene deliveries). At this level, the loss of RFG pipeline supplies could be alleviated by local gasoline production and inventories.
 - An explosion or fire in one or more of the major refineries, at a seaport, or along a major pipeline that is the key to supplying RFG to a particular area of the country.

The point is not to predict such an occurrence but to plan how the Federal, State, and local governments will deal with such a situation if and when it should occur. To prepare for these situations, the EPA is forming a task force to develop plans to expedite resolving difficulties should they arise. Plans may include waivers for the use of non-U.S. flag ships, and the waiver of trucker driving hours and truck weight limits.

Survey Results and Other Findings

Following are summaries of survey results and other findings that should be considered during the implementation of the RFG program.

- **Company Surveys**
 - Surveys were sent to 152 refiners, blenders, bulk terminal operators, importers, pipelines, and tanker and barge operators. The results of the survey are analyzed in the following chapters and summarized in Volume 2, Appendix B. Responses were received from 119 companies.
 - Companies provided comprehensive information on plans/estimates for RFG production.

- Little information was provided on plans/estimates for RFG inventories. Companies either indicated that their plans were incomplete or they declined to provide the information for business purposes. EIA developed its own inventory profile using the RFG production data provided by the companies.

RFG Supply/Demand Market Clearing Estimates-January 1995
(Thousand Barrels per Day)

Region	Production	Inter-PADD Movements	Imports	Stock Build	Supply	Demand
PADD I (East Coast)	624	685	174	54	1,431	1,431
PADD II (Midwest)	297	56	0	12	341	341
PADD III (Gulf Coast)	1,005	(749)	0	10	247	247
PADD IV (Rocky Mountain)	0	0	0	0	0	0
PADD V (West Coast)	513	7	0	20	500	500
U.S.	2,439	0	174	96	2,519	2,519

Source: EIA estimates.

• **RFG Supply**

- EIA estimates that RFG supplies will be adequate to meet U.S. and regional demands for RFG on January 1, 1995. There appears to be enough RFG surge production capacity to meet small unexpected rises in the demand for RFG, or minor disruptions to the supply of RFG. As the year progresses, RFG demand is expected to increase, tightening the supply situation.
- The stock build for January is estimated at about 96 MBD, or approximately 4 percent of forecasted RFG demand. Total finished gasoline stock builds for January averaged approximately 6 percent of demand from 1990-1994. If stock builds are lower in January, the possibility for outages in the summer driving season increases.
- Import contracts have been signed by a number of companies. Survey respondents indicated that approximately 174,000 barrels per day of RFG imports are expected in PADD I (about 12 percent of PADD I RFG demand) when the program is implemented.

- EIA's industry survey did not identify any refinery closures due to the new regulations.
 - In order to maintain as much fungibility in the distribution system as possible, refiners that responded to the survey reported that they are using EPA's Simple Model to produce RFG.
 - The allowability of in-line blending was mentioned by a number of companies as a potential problem that could constrain RFG production. As of this writing the EPA believes that the potential constraints have been resolved with the companies.
- **Oxygenate Supply**
 - Based on information gathered through our surveys and through discussions with government and industry, EIA believes that there will be adequate oxygenate supplies for the start-up and implementation of the RFG program.
 - Plans for delivering and blending ethanol into RFG at new locations, however, are tenuous at best. At issue is whether there is enough barge, rail, and truck capacity to deliver ethanol from distilleries in PADD II to new market areas in PADD I. The Renewable Oxygenate Standard (ROS) portion of the RFG program is unresolved at this time. A Federal Appeals Court hearing will be held in early 1995 to determine if, when, and how the ROS program is to be implemented.
 - **Deliverability--Supply Distribution**
 - Although supplies appear to be adequate, questions remain about the deliverability of RFG. As a result of the RFG regulations, an increased number of products requiring segregation must be delivered through a fixed capacity pipeline system and then transferred and stored in the same number of tanks that were present before the requirements.
 - Particularly vulnerable are terminal storage locations at the end of the distribution system, rural locations with a single supplier, and areas where tankage availability will cause a supplier to choose one product over another.
 - Some areas will no longer be served by their traditional fuel suppliers and new suppliers will have to enter these markets. Some dislocations could occur until the new suppliers are in place.
 - Exchange agreements between suppliers face major restructuring, which could impede rapid adjustments to unexpected local supply problems.
 - Shortages should be corrected by the market in relatively short periods of time and could be accompanied by price run ups until the situation stabilizes.

- **Storage**

- Tankage to store RFG or its component parts are expected to be ready throughout the system. However, the adequacy of tankage for *both* RFG and conventional products is uncertain.
- In many instances choices must be made as to what product to carry as storage capacity is limited from the refinery to the retail outlet.

- **The Impact on Other Petroleum Products**

- Because additional oxygenates will increase the total supply of gasoline, reduction in the manufacturing of other refined products is not expected.
- Heating oil inventory builds for the coming winter are proceeding rapidly. Total distillate fuel oil stocks are currently about 15 million barrels ahead of last year's pace, with East Coast heating oil inventories slightly higher than last year. According to industry sources, both secondary and consumer inventory building are ahead of last year. Primary supplies appear adequate.
- Heating oil and propane will, however, compete for space in the distribution system with RFG. In the event of a sudden and large demand surge brought on by severe cold weather or other such events, pressure may be put on the deliverability of RFG.

- **Information Dissemination**

- An enormous amount of data and information must be distributed to every company and consumer that will be involved in the implementation of the RFG program.
- The degree to which all those involved in the process (Federal, State, and local government officials, the American Automobile Association (AAA) and other associations, consumers, automobile mechanics, retail gasoline station operators, etc.) are informed about how they will be affected and how industry plans to respond to problems will influence the public's reaction.
- EPA has established a task force that includes representation from government, associations, industry, the media and the public to take a proactive role in the dissemination of information related to the RFG program. DOE and EIA are assisting EPA in this effort.
- EIA has the mechanisms in place to collect and disseminate data collected weekly and monthly on the production, importation, distribution and storage of RFG at the primary level as soon as RFG supplies appear.

1. Introduction

Study Approach

The Energy Information Administration (EIA) initiated a study to assess the implementation of the reformulated gasoline (RFG) program at the request of Congressman John Dingell, Chairman of the Subcommittee on Oversight and Investigations. After initial discussions with the Subcommittee staff, a two-part study was decided on, each of which would involve interaction with Department of Energy (DOE) and Environmental Protection Agency (EPA) staff as well as the suppliers, distributors, and consumers of RFG. EIA was asked to perform an objective analysis by October 3, 1994, using available data and information. EIA was to consider those problems that might be expected to occur during the start-up of the RFG program in early 1995, and to describe those events that could potentially cause significant disruptions to the program over the longer term.

Part I of the study is largely based upon planning estimates and forecasts developed in advance of the actual production, importation, and stocking of RFG. Part II will update the initial report as the actual RFG situation becomes more apparent.

Part I

Part I of the study was conducted in a three-month time frame. The effort involved:

- Reviewing publicly-available studies and analyses and the various outlooks for RFG
- Collecting and compiling information and data gathered at meetings between DOE, EPA, industry, and other parties
- Discussions with individual refining, pipeline, importing, storing, and tanker and barge companies about their plans for supplying RFG and problems they expect to encounter in supplying RFG to all required areas
- Analyzing the results of voluntary surveys that went to refiners, importers, pipeline operators, bulk terminal operators, and tanker and barge operators requesting their October 1994 through January 1995 month-by-month plans for the production, importation, and inventories of RFG, the problems anticipated in supplying RFG to all required areas, anticipated reporting problems, and other relevant information
- Evaluating information on the petroleum refining and distribution system garnered from historical data collection and validation activities and previous studies

- Assessing the feasibility of the industry's strategies for producing and distributing the RFG supplies necessary to meet expected demand and the associated problems
- Determining the status of the RFG regulatory implementation and enforcement processes.

Part II

Part II of the study will be conducted during October and November 1994. The purpose of this part of the study is to update the supply estimates and findings with more current planning data before the RFG regulations take effect at bulk terminals on December 1, 1994, and at the pump on January 1, 1995. EIA intends, if necessary, to re-survey prospective problem areas and to utilize these results along with actual data collected during September, October, and November as the basis for updating the findings.

RFG Program Requirements and Implementation

The Clean Air Act Amendments of 1990 (CAAA90) require RFG to be the only gasoline sold in the nine most severe ozone nonattainment metropolitan areas.¹ In addition to these mandatory areas, States may apply to the Environmental Protection Agency (EPA) on behalf of any moderate or serious ozone nonattainment areas in their State in order to opt into the program. So far, 14 States and the District of Columbia applied and were approved to opt into the program (see Appendix C).² Figure 1.1. shows the nonattainment areas where RFG will be required to be supplied as of January 1, 1995. Figure 1.2. portrays selected milestones in the motor fuel regulation program. Appendix D in Volume 2 of this report provides detailed information concerning RFG Testing and Documentation.

The regulations implementing the RFG program were issued as part of a two-phase program. All refiners producing RFG are required to certify that their gasoline meets the fuel content specifications and/or performance standards as promulgated by EPA. Under phase I of the RFG program, RFG will be required beginning January 1, 1995, in the mandatory ozone nonattainment areas, and in the nonattainment areas of those States which opted into the program. Reformulated gasoline must be available by December 1, 1994, at product terminals serving retailers in nonattainment areas. The RFG program covers the entire calendar year. Phase II of the program begins on January 1, 2000, and requires a 20-percent reduction in toxic air pollutants³ (TAPs) emissions and a 5-percent reduction in oxides of nitrogen (NOx) emissions as compared to a refiner's 1990 baseline gasoline. New baselines are required to establish further

¹ These ozone nonattainment areas are Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, and San Diego.

² The areas that have already been approved include sections of Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Texas, Virginia, and the District of Columbia. Wisconsin applied in May, 1994 and the moderate nonattainment areas will not be included in the program until 6/1/95.

³ TAPs include benzene, 1,3 butadiene, formaldehyde, acetaldehyde and polycyclic organic matter.

reductions in volatile organic compounds (VOC) emissions. This report does not deal with phase II of the program.

Phase I of the program will be implemented in two stages through the use of the Simple and Complex Models. The Simple Model may be used from January 1, 1995, through December 31, 1997, and requires that gasoline contains a maximum benzene content of 1 percent by volume, no heavy metals or lead additives, a minimum oxygen content of 2 percent by weight, and result in at least a 15-percent reduction in VOCs⁴ and TAP emissions as compared with emissions from 1990 gasoline baseline properties. No increase in NOx emissions is permitted over the level emitted using the 1990 baseline. In order to determine whether fuels meet the performance requirements of RFG under the Simple Model, EPA requires that baseline gasoline properties and performance be established for every refinery facility and importer of gasoline into the United States. A lower Reid Vapor Pressure (RVP) for the gasoline is required during the summer high ozone season (June 1 to September 15) to reduce the emissions of ozone forming VOCs. During the high ozone season, the United States is divided into two regions with an RVP of 7.2 psi required in VOC Control Region I (Southern areas), and an RVP of 8.1 psi required in VOC Control Region II (Northern areas). Appendix C of Volume 2 summarizes the State Implementation Plans. The TAP emissions reduction requirement applies throughout the entire year.

The regulations allow the oxygenate to be blended into the RFG downstream from the refinery. The RFG blendstock, reformulated gasoline blendstock for oxygenate blending (RBOB), intended for downstream oxygenate blending, must meet all RFG standards, except the oxygen standard. The downstream oxygenate blenders are responsible for meeting the oxygen standard for RFG produced using RBOB.

Under Federally mandated State programs, some ozone nonattainment areas that are also classified as carbon monoxide nonattainment areas require that the RFG sold in those areas contain a minimum of 2.7 percent oxygen by weight during at least four winter months. At the end of the oxygenated gasoline season, the oxygen content of the RFG is reduced to 2.0 percent by weight.

Product differentiation has increased within the motor gasoline category as a result of RVP regulations, oxygenated and RFG programs. Fungibility of gasoline has always been an essential factor for the efficient operation of the fuel distribution system in the United States. Today there are over 250 possible types of conventional, oxygenated, and reformulated gasolines.

The Complex Model may be used beginning January 1, 1995, and is mandatory beginning January 1, 1998. It expands the performance standards that a refiner must meet in order to certify its fuel as RFG based on various parameters such as oxygenate type, sulfur content, olefin content, and fuel distillation. Though refiners are allowed to choose either the Simple Model or the Complex Model for the 1995-1997 period, they must remain consistent with the model they choose. Switching back and forth between models is not permitted. Beginning on January 1, 1998, all refiners will be required to use the Complex Model to certify their RFG.

⁴ VOCs include all oxygenated and non-oxygenated hydrocarbons except methane and ethane.

Figure 1.1. Areas Requiring the Use of Reformulated Gasoline as of January 1, 1995

Sources: Environmental Protection Agency (EPA), Regulation of Fuels and Fuel Additives; Standards for Reformulated and Conventional Gasoline; Final Rule," (Washington, D.C., December 15, 1993), "Regulation of Fuels and Fuel Additives: Standards for Reformulated and Conventional Gasoline," (Washington, D.C., June 30, 1994), "Reformulated Gasoline and Anti-Dumping Questions and Answers," (Washington, D.C., July 1, 1994).

Figure 1.2. Selected Milestones in Motor Fuel Regulation

¹CAA passed in 1970; CAAA passed in 1977.

The RFG regulations also require that the conventional gasoline sold by each refiner or importer does not increase certain emissions over the quantities produced on an average per gallon basis using their 1990 baseline. Under the Simple Model, the sulfur, T-90, and olefin content may not exceed 125 percent of the 1990 baseline and exhaust benzene may not exceed 1990 baseline levels. Under the Complex Model beginning in 1998, exhaust toxics and NO_x emissions of conventional gasoline may not exceed 1990 baseline levels. This requirement maintains the quality of conventional gasoline and ensures that refiners do not "dump" fuel components not allowed in RFG (or restricted, such as benzene) into conventional gasoline.

On June 30, 1994, the EPA issued a ruling on renewable oxygenates in RFG, commonly referred to as the Renewable Oxygenate Standard (ROS). The ROS program was to be phased in over 2 years and requires at least 15 percent of the required 2.0 percent by weight oxygen content in each refinery's annual production of RFG be derived from renewable oxygenates during 1995 and at least 30 percent in 1996 and for each year thereafter. Renewable oxygenates had to meet two criteria to comply with the requirements of the program. First, they had to be produced from non-fossil fuel feedstocks, or their oxygen content had to be derived from oxygenates produced

from such feedstocks. Second, to be considered "renewable" when blended into VOC-controlled RFG, the oxygenate must not cause an increase in the fuel's volatility. EPA allowed renewable oxygenate credits to be earned and traded. Credits were earned if more than 15 percent of the oxygenate required to produce RFG during 1995 is renewable oxygenates and by blending greater than 30 percent in subsequent years. Refiners may average the renewable oxygen content of RFG over the calendar year. However, during the first year of the program, the averaging period was to cover a 13-month period from December 1, 1994, through December 31, 1995, to ease the transition. As a result of the EPA's ruling on renewable oxygenates in reformulated gasoline, the American Petroleum Institute and the National Petroleum Refiners Association filed a lawsuit against the EPA seeking an emergency stay pending judicial review of the ROS program. This has been granted. The court has indicated that hearings will be held in early 1995 to determine if, when, and how the program will be implemented.

Each refinery, importer, or oxygenate blender has the option of meeting the requirements for oxygen, benzene content, and VOC and TAP emissions reductions, through either a per-gallon basis or an average basis using their total gasoline output over an averaging period. The refiners, importers, and blenders may use either the per-gallon or average standard for each parameter. The standards for the averaging program are more stringent than those for the per-gallon basis. The averaging standards require a VOC and TAP emissions reduction of 16.5 percent instead of 15 percent and the average benzene standard is 0.95 volume percent whereas the per-gallon benzene standard is 1.0 volume percent.

Any person who refines, blends, imports, and certifies RFG and who uses the averaging program may earn credits by achieving greater reductions in benzene, or by using a higher oxygen content than required. Benzene and oxygen credits may be traded across RFG areas and a refiner with more than one refinery may transfer credits from one of its refineries to another. Credits may not be saved for use in later years and may only be used in the year in which they are earned.

2. RFG Supply Estimates

Overview

Supply of RFG is projected to be adequate to cover expected demand at the startup of the RFG program in January 1995. Results from the EIA's Refinery Operations and Import Operations questionnaires and estimates of supply from nonrespondents indicate that planned supply of RFG is very closely balanced with expected demand and inventory build with little excess production. The Northeast States and Southern California have very high demands for RFG and it appears that refiners in those regions will be producing RFG at or near their maximum capability. Production of RFG by refineries located in the Northeast (primarily Delaware, Pennsylvania, and New Jersey) will be supplemented by deliveries from the Gulf Coast and imports. On the West Coast, Southern California refiners expect to produce enough RFG to meet demand.

Background

Reformulated motor gasoline supply may come from domestic refineries or imports. Refiners and importers may supply RFG directly or produce reformulated blendstock for oxygenate blending (RBOB) for blending with oxygenates (i.e., ethanol, MTBE, ETBE, or TAME) at downstream terminals. EIA surveyed refiners (Refinery Operations Questionnaire) and requested production forecasts of RFG, RBOB, oxygenated gasoline, and conventional gasoline for the months of October 1994 through January 1995. Importers were requested to provide estimates of RFG imports for those same months (Import Operations Questionnaire).

Responses to these surveys provided the foundation for an EIA estimate of reformulated, oxygenated, and conventional gasoline supply. This chapter reviews the survey results and the procedures followed to validate the survey data and to derive production forecasts to cover survey nonrespondents. The supply forecast for January 1995 developed by this procedure is presented as the "EIA Market Clearing Estimate."

Survey Response

The EIA Refinery and Import Operations Questionnaires solicited projections of planned production and imports for the months of October 1994 through January 1995 from U.S. refiners, blenders, and importers. Domestic refiners that responded to the survey represent about 86 percent of the total domestic gasoline supply. The response from domestic refiners that are expected to produce RFG during the period October 1994 through January 1995 was about 92 percent. In cases where no response was received and where responses were incomplete, production and import forecasts were estimated by EIA analysts.

EIA's January 1995 Market Clearing Estimate of gasoline supply, derived from the surveys and EIA's estimates of supply from nonrespondents, indicate that nearly 82 percent of the total RFG supply will come from Petroleum Administration for Defense Districts (PADDs) I, III, and V (Table 2.1). Imports will make up almost 7 percent of the RFG supply.

Table 2.1. EIA Market Clearing Estimate of Motor Gasoline Supply by PADD, January 1995
(Thousand Barrels per Day)

Supply Source	Gasoline Type			Total Gasoline
	Conventional Unleaded	Oxygenated	RFG	
PADD I	158	8	624	790
PADD II	1,367	136	297	1,800
PADD III	2,170	87	1,005	3,262
PADD IV	187	40	0	227
PADD V	183	550	513	1,245
Imports	40	0	174	214
Total	4,105	821	2,613	7,538

Source: EIA estimates.

RFG Supply

Domestic refiners that produce motor gasoline and responded to the EIA Refinery Operations Questionnaire fell into one of six categories based on their response to EIA's request for a production forecast by type of gasoline for the months of October 1994 through January 1995. Responding refineries indicated that they either would or would not produce RFG. Refiners that indicated they would produce RFG either provided a complete production forecast for all types of gasoline, provided a forecast for RFG only (but not oxygenated or conventional), or did not provide any production forecasts. Refiners that reported they would not produce RFG provided either a complete conventional/oxygenated gasoline production forecast or did not provide any production forecasts. The survey responses according to these categories are provided in Table 2.2.

Two important observations may be made from Table 2.2. First, *refiners that responded to the EIA survey (survey response categories 1 through 5) represent over 86 percent of the total gasoline produced in January 1994.* Refiners that provided projections of gasoline production for all types of gasoline (categories 1 and 4) accounted for about 58 percent of the total January 1994 gasoline output. Refiners that provided forecasts of RFG production (categories 1 and 2) account for about 92 percent of expected domestic RFG production in the Market Clearing Estimate.

Table 2.2. Refinery Gasoline Production Forecast by Survey Response Category, January 1995
(Thousand Barrels per Day)

Survey Response Category	Will Refiner Produce RFG?	Response to Gasoline Production Forecast Request	January 1994 Gasoline Production	Survey Results of Gasoline Production Forecast, January 1995	
				RFG	Total Gasoline
1	Yes	Complete	3,285	1,931	3,675
2	Yes	RFG only (or incomplete)	1,195	323	399
3	Yes	None	164	NA	NA
4	No	Complete	727	0	792
5	No	None	639	0	NA
6	Unknown	Nonrespondent	966	NA	NA
Totals			6,977	2,254	4,865

NA = Not Available.

Notes: Volumes exclude imports. RFG volumes include RBOB. Totals may not equal sum of components due to independent rounding.

Source: EIA estimates.

Second, refiners that will produce RFG and provided a complete production forecast (category 1) *project total gasoline production in January 1995 to increase by more than 10 percent compared to January 1994*. Refiners that do not plan to produce RFG and gave complete projections (category 4) also reported a large increase in planned total gasoline production of nearly 8 percent. This large planned increase in output implies that refiners either expect a significant increase in total gasoline demand, or that they are overly optimistic in this early planning stage.

Motor gasoline demand during January 1995 is forecasted to average 7,288 thousand barrels per day, which is a 5.4 percent increase over the average January 1994 demand of 6,916 thousand barrels per day.⁵ The unusually cold weather and frequent snowstorms in the eastern United States during January 1994 restricted automotive travel.

Nevertheless, the supply forecasts provided by survey respondents do appear optimistic. Analysis of survey responses by individual refiners indicates that the oversupply is restricted to conventional gasoline and EIA's correction for this bias is detailed below. Forecasts of RFG supply do not appear biased and are very closely balanced against projected demand and inventory build. The significantly higher costs of producing RFG compared to conventional gasoline should justify more accurate assessments of RFG production by refiners.

⁵ Average 1995 demand, however, is expected to increase by only 1.1 percent over 1994 (Energy Information Administration, *Short Term Energy Outlook*, Third Quarter 1994, DOE/EIA-0202(94/3Q) (Washington, DC, August 1994).

Data validation for refiners' motor gasoline production forecasts and estimation of gasoline production for nonrespondents involved three steps. First, motor gasoline production forecasts provided by survey respondents were compared to historical production rates for each refinery, and estimates of production for nonrespondents were derived from historical production rates. Second, RFG production forecasts by company were compared to forecasts published in other industry studies.⁶ Third, production forecasts were compared to expected demands and inventory change for each type of gasoline by company and by region.

From this analysis several adjustments were made. About 275 thousand barrels per day of conventional gasoline were reclassified as oxygenated gasoline to reflect downstream blending with ethanol, MTBE, or other oxygenates. Oxygenated gasoline production projected by refiners in sub-PADDs IA and IB (40 thousand barrels per day) was reclassified as RFG with 2.7 weight percent oxygen (OPRG).⁷ Projected RBOB production volumes were reclassified as RFG by multiplying by 1.1 to account for the approximate increase in volume due to the addition of oxygenates. Finally, projected conventional gasoline production was reduced by 236 thousand barrels per day (5.4 percent) based on the analysis outlined above.⁸

Tabulation of production forecasts from survey respondents, estimation of production for survey nonrespondents, and adjustment of the production forecasts resulted in EIA's Market Clearing Estimate of Supply for January 1995 (Table 2.1).

The EIA Market Clearing Estimate of supply satisfies the projected gasoline demand and yields a total gasoline inventory build of about 7.8 million barrels during January 1995. Primary stocks of RFG (including stocks in refinery and bulk terminal tanks and pipelines) are expected to reach 53 million barrels by December 31, 1994. Reformulated gasoline stocks are expected to increase by an additional 3.0 million barrels during January 1995.

Reformulated motor gasoline will primarily be produced by the large complex refineries that benefit from economies of scale and have the necessary secondary processing units to produce motor gasoline with low Reid Vapor Pressure (RVP), as well as low benzene and aromatics. ***Over 97 percent of the RFG market will be supplied by large refiners*** (Table 2.3).

Several other organizations have assessed the capability of the domestic refining industry to supply RFG. Table 2.4 compares EIA's Market Clearing Estimate forecast with other recent comprehensive appraisals: EIA's *Annual Energy Outlook, 1994* (AEO94), the National Petroleum Council (NPC), and Bonner & Moore.

⁶ For example, Bonner & Moore Associates Inc., *Reformulated Gasoline: Cost, Distribution, and Compliance Implications*, (Houston, TX, June 1994).

⁷ Reformulated gasoline must be sold in all areas of the Northeast that required oxygenated gasoline during the past two winters. Thus, there is no demand for conventional oxygenated gasoline in the markets supplied by most refiners in PADDs IA and IB. The EIA Refinery Operations Survey was ambiguous in that it did not ask for a production forecast for OPRG as a separate category.

⁸ PADD II conventional gasoline production was reduced by 62 thousand barrels per day, PADD III reduced by 61 thousand barrels per day, PADD IV reduced by 24 thousand barrels per day, and PADD V reduced by 89 thousand barrels per day.

Table 2.3. Projected RFG Production by Size of Refiner, January 1995
(Barrels per Day)

	Size of Refiner (Total Crude Oil Primary Distillation Capacity)			
	Over 100,000		100,000 and less	
Number of Refiners	34		54	
Number of Refineries	108		63	
Total Crude Oil Distillation Capacity	13,690	(90.4%)	1,454	(9.6%)
Estimated RFG Production	2,383	(97.7%)	56	(2.3%)

Note: Estimated RFG production includes RBOB.
Source: EIA estimates.

Table 2.4. Comparison of 1995 RFG Domestic Production Forecasts by PADD
(Thousand Barrels per Day)

Study	Petroleum Administration for Defense District					U.S. Total
	I	II	III	IV	V	
EIA Market Clearing Estimate	624	297	1,005	0	513	2,439
NPC Survey	430	358	857	0	926	2,571
Bonner & Moore	560	329	856	NA	NA	NA
EIA AEO94	386	577	1,084	0	536	2,583

NA = Not Available.

Sources: NPC Survey: National Petroleum Council, *U.S. Petroleum Refining* (Washington, DC, August 1993). Bonner & Moore: Bonner & Moore Associates, Inc., *Reformulated Gasoline: Cost, Distribution and Compliance Implications* (Houston, TX, June 1994). EIA AEO94: Energy Information Administration, *Annual Energy Outlook, 1994*, DOE/EIA-0383(94) (Washington, DC, January 1994).

Differences in total RFG supply forecasts in Table 2.4 are primarily driven by differences in demand forecasts (refer to Chapter 3, "RFG Demand Estimates," for a description of the differences). The EIA Market Clearing Estimate and the NPC survey are based on individual refiner surveys. The Bonner & Moore and AEO94 forecasts are based on refining industry linear programming models.⁹ All of the forecasters identified PADD III as the swing producer, accounting for between 33 percent and 42 percent of the domestic RFG production.

⁹ For example, Bonner & Moore assumed that after oxygenate addition, the 1 percent limit on benzene was the most difficult requirement for the refiners to achieve. Refineries that had reformer prefractionation and aromatics extraction were assumed to be capable of 100 percent RFG production. Refineries having only one or the other capabilities could produce between 60 percent and 80 percent RFG and other configurations were assumed to result in a smaller share of RFG. Another consideration was given to crude oil quality. Those refiners with access to light, sweet crudes could also produce a larger share of RFG.

RFG Imports

Gasoline imports will be an important source of marginal supplies during the RFG program. This section discusses historical import patterns and the sources of RFG imports.

Import Patterns

EIA surveyed importers of motor gasoline, with an Imports Operations Questionnaire, and requested a forecast of RFG imports for the months of October 1994 through January 1995. The survey results are provided in Table 2.5.

Table 2.5. Projected Reformulated Gasoline Imports
(Thousand Barrels per Day)

October 1994	128
November 1994	132
December 1994	128
January 1995	174

Source: EIA Import Operations Questionnaire.

Table 2.6 shows the countries that have exported the most gasoline to the United States over the past several years. PADD I is the most heavily dependent upon imports, which supply approximately 10 percent of the demand in the region, with Canada, Venezuela, and the Virgin Islands figuring prominently.¹⁰

Survey respondents mentioned the possibility of importing RFG not only from Canada and Venezuela, but also from Saudi Arabia, Belgium, Italy, and other countries that have supplied gasoline in the recent past. There is uncertainty as to whether the imports will be RFG or RBOB, and some regulatory issues are not yet resolved (see below). It does not appear that the United States will become increasingly dependent upon imports to supply its gasoline needs in the short-term because of the RFG program.

EIA's Market Clearing Estimate for total RFG imports is greater than other published forecasts (Table 2.7). The lower demand forecasts in other industry studies compared to EIA's Market Clearing Estimate of Demand (see Chapter 3, RFG Demand Estimates) contributes to the lower RFG import estimates.

¹⁰ Although deliveries from the Virgin Islands and Puerto Rico are classified "imports" in this report, refineries in these islands qualify as domestic refineries under the reformulated gasoline program regulations.

Table 2.6. Major Sources of U.S. Finished Gasoline Imports
(Thousand Barrels per Day)

	1990	1991	1992	1993	1994 *
PADD I					
Canada	42.0	48.2	45.3	48.4	49.7
Venezuela	65.0	48.3	51.2	39.0	29.1
Saudi Arabia	30.3	33.7	27.8	15.8	1.9
Virgin Islands	41.6	42.1	36.5	45.5	101.5
Brazil	21.7	15.6	15.9	27.6	26.1
PADD II					
Canada	5.8	9.1	5.6	2.5	2.5
PADD III					
Brazil	1.6	0.0	0.7	0.8	4.0
Virgin Islands	4.0	2.1	3.1	2.3	2.2
PADD IV					
Canada	1.3	1.3	1.1	0.3	0.4
PADD V					
Canada	5.0	8.8	9.1	3.2	2.3
China	0.8	3.5	4.0	0.4	1.3

* 1994, January through May.

Sources: Energy Information Administration, *Petroleum Supply Annual 1993*, DOE/EIA-0340(93) (Washington, DC, June 1994 and earlier issues), and *Petroleum Supply Monthly*, July 1994, DOE-EIA-0190(94/07) (Washington, DC, July 1994).

Table 2.7. Imports of RFG by PADD
(Thousand Barrels per Day)

Study	I	II	III	IV	V	Total
EIA Market Clearing Estimate	174	0	0	0	0	174
EIA AEO94	28	10	61	0	5	104
NPC LP Results	36	0	0	0	32	68
Bonner & Moore	114	0	0	NA	NA	114
Wright Killen	100	NA	NA	NA	NA	100

NA = Not Available

Sources: NPC Survey: National Petroleum Council, *U.S. Petroleum Refining* (Washington, DC, August 1993). Bonner & Moore: Bonner & Moore Associates, Inc., *Reformulated Gasoline: Cost, Distribution and Compliance Implications* (Houston, TX, June 1994). EIA AEO94: Energy Information Administration, *Annual Energy Outlook 1994*, DOE/EIA-0383(94) (Washington, DC, January 1994).

The Baseline Issue

Venezuelan refiners could produce 100 thousand barrels per day (MBD) of RFG for export to the United States. For various technical reasons, including the types of crude oil used as inputs to the refineries, Venezuelan gasoline is not as clean as the average gasoline sold in the United States. When the EPA rules came out, Venezuela insisted that it be permitted to produce RFG in 1995 using its own 1990 gasoline characteristics as a baseline for reduction of toxic emissions. The EPA, instead, ruled in December 1993 that foreign refiners would have to work from a 1990 baseline for reductions of gasoline emissions using the national average for gasoline sold in the United States.¹¹

Venezuela objected to the EPA clean gasoline requirements by demonstrating that their gasoline composition falls within the characteristic ranges of gasoline produced for the Northeast United States, as shown in Table 2.8.¹² In addition, Venezuela argued that by not being treated equally with U.S. refiners, the United States was violating the General Agreement on Tariffs and Trade (GATT).

Table 2.8. Characteristics of Unleaded Regular Gasoline

	Venezuela, 1990 (average)	Northeast U.S., 1990 (range)
Olefins (volume percent)	22.0	3.5 - 26.8
Sulfur (ppm)	644	70 - 1,090
Aromatics (volume percent)	20.1	19 - 41
Benzene (volume percent)	0.7	0.54 - 2.24

ppm = parts per million.

Sources: C.L. Dickson, "Motor Gasolines, Summer 1992," National Institute for Petroleum and Energy Research, NIPER-178 PPS, 93/1 (Bartlesville, OK, January 1993), and *Octane Week*, April 25, 1994, p. 4.

On May 3, 1994, the EPA issued a proposed ruling to allow Venezuela to establish its own baseline, and on May 23, 1994, they held a public hearing. The public comment period closed June 23, 1994. The EPA has delayed a final ruling on this issue, causing uncertainty among importers.¹³ (See Preface for the latest status of this issue.)

If the baseline issue is not resolved in Venezuela's favor, Venezuela may export only 40 to 60 MBD of RFG. In the future, as other countries move towards cleaner fuels, even less RFG will be made available to the United States.

¹¹ "Venezuela Stung by Environmental 'Protectionist' Agency," *Energy Compass*, December 17, 1993.

¹² *Octane Week*, April 25, 1994, p. 4.

¹³ *Petroleum Intelligence Weekly*, August 29, 1994, p. 8.

Oxygenate Supply

This section examines the projected supply of oxygenates, some of the key components in RFG. *EIA projects that there will be ample total supply of oxygenates to meet demand.*

The Uses of Oxygenates

Oxygenates are liquid organic compounds. Oxygenates may reduce carbon monoxide emissions, as in oxygenated gasoline, or reduce the precursors of ozone pollution, as in RFG. The two primary oxygenates used in gasoline blending are ethanol and methyl tertiary butyl ether (MTBE). In the United States, ethanol is primarily derived from milling corn, while MTBE is made from methanol produced from natural gas and isobutylene produced from crude oil and natural gas liquids. One gallon of ethanol contains approximately twice the amount of oxygen as one gallon of MTBE.¹⁴ However, unlike MTBE, gasoline containing ethanol cannot be transported in pipelines because ethanol has an affinity for water, which greatly complicates its deliverability. Prior to passage of the Clean Air Act Amendments of 1990, 10 percent by volume ethanol was blended with 90 percent by volume gasoline and marketed as "gasohol." In contrast, MTBE primarily had been used as an octane booster since the mid-1970s.

Two other oxygenates may become important in the future, but are unlikely to be a significant factor in the first year of the RFG program. They are tertiary amyl methyl ether (TAME), made from methanol and isoamylene (produced from crude oil), and ethyl tertiary butyl ether (ETBE), made from a combination of ethanol and isobutylene. U.S. TAME production capacity was only 14.5 MBD on January 1, 1994, while ETBE production capacity was less than 1 MBD.¹⁵ The proposed EPA requirement that 15 percent of the RFG contain oxygenates produced from renewable resources, which in practice means ethanol, may make ETBE very important in the summer months when it produces fewer volatile organic compounds emissions than ethanol,¹⁶ but it will not be a factor in the transitional period.

Oxygenates Capacity and Production

Capacity for producing MTBE and ethanol for both clean air and octane enhancing purposes has grown steadily in recent years. U.S. fuel ethanol capacity has grown from 83 MBD on

¹⁴ For pure MTBE and ethanol, 1 gallon of ethanol = 2.03 gallons of MTBE. In practice, however, MTBE is less than 100 percent pure and fuel ethanol may be mixed with several percent denaturing agents. These differences could result in small changes in the total MTBE equivalent calculations done in this report, but relative comparisons of different estimates are still possible.

¹⁵ ARCO Chemical Company operates a plant in Corpus Christi, Texas, which can quickly be converted from producing 12,000 barrels per day of MTBE to 9,500 barrels per day of ETBE. Discussions with industry sources indicate several other U.S. plants could be converted in a few weeks from MTBE production to ETBE production, but with a smaller volume of output.

¹⁶ To control emissions of volatile organic compounds (VOCs), ethanol does not qualify as a renewable resource during the summer.

January 1, 1991, to 91 MBD on January 1, 1994. MTBE capacity increased from 123 MBD to 227 MBD in the same period.¹⁷

EIA and several private sector companies have estimated oxygenate capacity and production for 1995, as shown in Table 2.9 and Table 2.10. The MTBE-equivalent conversion factor of 2.03 used in Table 2.10 represents the additional oxygen content in ethanol compared to MTBE.

Table 2.9. U.S. MTBE Production Forecasts
(Barrels per Day)

	EIA	DeWitt	IRI	Bonner & Moore
Average 1995 Capacity	275,803	246,470	259,500	264,050
Capacity Utilization Factor	0.83	0.85	0.83	0.83
Projected 1995 Production	228,916	209,500	215,385	219,162

Sources: EIA: T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(94/07) (Washington, DC, July 1994), pp. 1-10. DeWitt: K. D. Miller, "Meeting the Renewable Oxygenate Requirement: Possibilities, Problems and Prospects," presented to 1994 DeWitt Gasoline-Oxygenate Workshop (Houston, TX, August 1994). IRI: Information Resources, Inc., from B. Haigwood and J. Stepan, "Oxygenated Fuels Industry Gears Up For Reformulated Gasoline," *Fuel Reformulation* (Denver, CO, March/April 1994), pp. 48-56. Bonner & Moore: Bonner & Moore Associates, Inc., "Reformulated Gasoline: Cost, Distribution, and Compliance Implications" (Houston, TX, June 1994).

MTBE production forecasts ranged from about 210 to 229 MBD, while ethanol production forecasts ranged from about 163 to 185 thousand MTBE-equivalent barrels per day.¹⁸ TAME production is expected to reach 16 MBD, or 14 MBD day MTBE-equivalent volume, while ETBE at this time is projected to be less than 1 MBD MTBE-equivalent volume.

MTBE net imports are projected by EIA to increase from 15,000 barrels per day in 1993 to 45,000 barrels per day in 1995, based on increased production capacity overseas and increased domestic needs.¹⁹ Ethanol imports are a minor factor, because of the 54 cents per gallon import

¹⁷ *Petroleum Supply Annual 1993*, Volume 1, DOE/EIA-0340(93)1 (Washington, DC, June 1994), p. 125, and B. Haigwood and J. Stepan, "Oxygenated Fuels Industry Gears Up For Reformulated Gasoline," *Fuel Reformulation* (Denver, CO, March/April 1994), pp. 48-56. Total includes the U.S. Virgin Islands.

¹⁸ The Bonner & Moore study had the low fuel ethanol production estimate, but also emphasized the amount of ethanol that is produced for industrial and other uses. Those sources are potential additional supplies of fuel ethanol.

¹⁹ MTBE imports have been as high as 43 thousand barrels per day in February 1994. Energy Information Administration, *Petroleum Supply Monthly* April 1994, DOE/EIA-0109(94/04) (Washington, DC, April 1994), p. 70.

Table 2.10. U.S. Fuel Ethanol Production Forecasts
(Barrels per Day)

	EIA	DeWitt	IRI	Bonner & Moore	Argonne
Average 1995 Capacity	105,218	109,038	107,370	94,462	104,957
Capacity Utilization Factor	0.85	0.825	0.85	0.85	0.85
Projected 1995 Production	89,435	89,956	91,265	80,292	89,213
MTBE Equivalent Conversion Factor	2.03	2.03	2.03	2.03	2.03
Projected 1995 MTBE Equivalent Production	181,554	182,611	185,268	162,994	181,102

Sources: EIA: T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(94/07) (Washington, DC, July 1994), pp. 1-10. DeWitt: K. D. Miller, "Meeting the Renewable Oxygenate Requirement: Possibilities, Problems and Prospects," presented to 1994 DeWitt Gasoline-Oxygenate Workshop (Houston, TX, August 1994). IRI: Information Resources, Inc., from B. Haigwood and J. Stepan, "Oxygenated Fuels Industry Gears Up For Reformulated Gasoline," *Fuel Reformulation* (Denver, CO, March/April 1994), pp. 48-56. Bonner & Moore: Bonner & Moore Associates, Inc., "Reformulated Gasoline: Cost, Distribution, and Compliance Implications" (Houston, TX, June 1994). Argonne: K. Stork, "The Impact of the Renewable Oxygenate Proposal on Ethanol Availability For Use as an Oxygenate in RFG, Oxygenated Gasoline and Gasohol," analysis memorandum, Argonne National Laboratory (Washington, DC, June 1994).

tariff that applies to most countries.²⁰ Ethanol exports are potentially a big factor, if shortages in Brazil become a continuing problem.²¹ (See Preface for the latest status on the Renewable Oxygenate Standard issue.)

Ethanol could have an inventory draw of about 11,000 barrels per day in January (see Table 2.11), and there would still not have to be a net drawdown for the entire year.²² Thus, if they can be delivered, on the national level oxygenates should be in adequate supply.

Historical Experience

The two oxygenated gasoline seasons illustrate how the industry reacts to marketplace changes over time. Figure 2.1 and Figure 2.2 show oxygenate stocks and production over time. The first oxygenated gasoline season ran from November 1992 through February 1993 for most

²⁰ T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," *Monthly Energy Review*, DOE/EIA-0035(94/07), p. 9.

²¹ Information Resources, Inc., estimates that ethanol exports to Brazil could be as high as 15,600 barrels per day in 1994 (240 million gallons for the year), which would be a significant percentage of domestic production if the demand continues into 1995. See *Octane Week*, August 22, 1994, p. 9.

²² Seasonal demand shifts will occur during the year. For example, if the industry is slow to use ethanol in the first few months and has to make it up later in the year, a 30 percent ethanol use in reformulated gasoline in one month would require an additional 24,000 barrels per day of ethanol, which would primarily come from inventory drawdowns.

Table 2.11. U.S. Oxygenate Supply Forecasts
(Thousand Barrels per Day)

	January 1995	1995 Annual Average
MTBE Production	223.7	228.9
MTBE Imports	46.0	45.0
MTBE Inventory Draw	41.2	10.0
Estimated Ethanol Production	89.4 ^a	89.4 ^a
Ethanol Production (MTBE-equivalent volume)	181.6	181.6
Estimated Ethanol Inventory Draw	11.0 ^a	0.0 ^a
Ethanol Inventory Draw (MTBE-equivalent volume)	22.3	0.0
Other Oxygenates Production	16.4 ^a	16.4 ^a
Other Oxygenates (MTBE-equivalent volume)	14.6	14.6
Projected Total Oxygenate Supply (MTBE-equivalent volume)	529.4	480.1

^a Figures are not part of the total.

Sources: Author's calculations using gasoline demand data from this report, and the following sources: T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(94/07) (Washington, DC, July 1994), pp. 1-10. K. D. Miller, "Meeting the Renewable Oxygenate Requirement: Possibilities, Problems and Prospects," paper presented to 1994 DeWitt Gasoline-Oxygenate Workshop (Houston, TX, August 1994).

regions. That season went smoothly, but not as predicted.²³ Demand for oxygenated gasoline and, in particular, for MTBE, was lower than widely expected. Prior to the season, there was concern that oxygenates might be in short supply; however, no supply shortages developed and prices of both oxygenates and oxygenated gasoline fell during the season. Stocks of MTBE peaked in August 1992, at 23.1 million barrels, while ethanol reached its highest level of nearly 3.0 million barrels in September 1992. Production of MTBE reached its highest level during the first season of 128,000 barrels per day in November 1992. The second oxygenated gasoline season, during the winter of 1993/94, also went smoothly, but with significant differences from the first oxygenated gasoline season.²⁴ Figure 2.1 and Figure 2.2 show that the second season was characterized by lower oxygenate stock levels and higher production, reflecting higher production capacity. Since RFG demand will be less seasonal than oxygenated gasoline demand, EIA has projected there will be an additional inventory drawdown of 10,000 barrels per day of

²³ "First Oxygenated Gasoline Season Shakes Out Differently Than Expected," *Oil & Gas Journal*, Oct. 25, 1993, pp. 66-75.

²⁴ C. Dale, "The Second Oxygenated Gasoline Season," *Petroleum Marketing Monthly*, DOE/EIA-0380(94/06) (Washington, DC, June 1994), pp. xiii-xix.

Figure 2.1. MTBE and Ethanol End-of-Month Stocks

MTBE in 1995.²⁵ In addition, because the oxygenated gasoline season began a month earlier in 1993/94, MTBE production increased sharply in September 1993 compared to a sharp rise in October the previous year. All these changes illustrate the industry's ability to react smoothly and promptly to the changing needs of the market.

Prices of Oxygenates

Prices of MTBE and ethanol since the beginning of the first oxygenated gasoline season are shown in Figure 2.3. As noted earlier, MTBE prices fell steadily during the first season. In 1992, ARCO Chemical, the world's largest MTBE supplier, changed their contract pricing from one based on octane enhancing value to one based on oxygenate value. Contract prices of MTBE reached a peak of \$1.10 per gallon in the summer of 1992, and most MTBE was sold at contract prices. The spot market prices shown in Figure 2.3 represent much smaller volumes, but are useful indicators of marginal MTBE costs. After trading as high as 98 cents per gallon in the summer of 1992 and 82 cents per gallon at the beginning of the season in October 1992, spot

²⁵ T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," *Monthly Energy Review*, DOE/EIA-0035(94/07), p. 9.

Figure 2.2. MTBE and Ethanol Production

MTBE prices fell steadily to a low of 71 cents per gallon in January 1993. Spot prices for MTBE also fell gradually during the second oxygenated gasoline season, falling from near 80 cents per gallon in October 1993 to near 60 cents per gallon in January 1994. A strike in Nigeria in mid-1994 pushed up crude oil and other energy prices.

Spot methanol prices also have had a significant effect on MTBE production. Spot Gulf Coast methanol prices rose from average 48 cents per gallon in 1994 to \$1.35 per gallon in August 1994, and spot MTBE prices rose to nearly \$1.00 per gallon in August 1994 as the demand for methanol grew while the economy was recovering. Soaring methanol prices have also discouraged MTBE production, and the 1994 high MTBE monthly average production of 154,000 barrels per day of MTBE in July 1994, was less than a year earlier, in spite of greatly increased production capacity. New methanol production is scheduled to come online at plants in Louisiana, New Zealand, and Venezuela at the end of 1994 or early in 1995, which may help alleviate potential methanol shortages.

Figure 2.3 shows ethanol prices since the beginning of the first oxygenated gasoline season. Prices fell throughout the first season in the winter 1992/93, along with MTBE and gasoline prices. Toward the end of the second season, in early 1994, prices rose as a failed sugar crop in Brazil caused sugar growers to use their crops more for sugar than for ethanol production, raising the world price of ethanol.

Figure 2.3. MTBE and Ethanol Spot Prices (U.S. Gulf Coast)

Ethanol prices are also complicated by tax factors. Ethanol is uneconomical to blend into gasoline without tax subsidies provided by the Federal Government and some States. Before January 1, 1993, the Federal Government provided a 54 cents per gallon tax subsidy for ethanol, if it was used for at least 10 percent by volume of gasoline. After January 1, 1993, the subsidy was changed for the oxygenated gasoline program to give a prorated amount for two other ethanol percentages: 7.7 percent by volume ethanol, which would bring the gasoline oxygen content up to the required 2.7 percent by weight level required in most carbon monoxide nonattainment areas, or 5.7 percent by volume ethanol, which would bring the oxygen content up to the 1.8 percent by weight oxygen level required in California.²⁶

The tax situation of ETBE is less apparent. The tax subsidy that the Federal Government provides may be used for offsetting Federal excise taxes.²⁷ Unlike ethanol, which economically can be splash blended downstream by companies who can use the tax credits, ETBE can be incorporated cheaply into gasoline in the refinery. But, many refiners cannot use the tax credit. Thus, the future of ETBE blending remains unclear.

²⁶ Source: Discussions with U.S. Department of the Treasury, Office of Tax Policy.

²⁷ There is also a provision for offsetting income taxes. However, this is potentially much less useful than a tax subsidy, because it necessitates having enough net income to offset the tax. Also, it cannot be used at all if a company is subject to the alternative minimum tax.

Domestic Refinery Production Capacity

Production of RFG will require significant changes to refinery operations and capital investment of up to \$4 billion.²⁸ Refiners must change operations to produce reformulated motor gasoline with reduced benzene and aromatics content, lower RVP, and added oxygenates.²⁹ The significant capital requirements present a concern that some refiners will be forced to shut down permanently because higher operating or capital costs make continued operations unprofitable. Crude oil atmospheric distillation capacity is commonly used as an approximate measure of refinery capacity. During the early 1980s, the domestic refining industry went through a dramatic period of capacity rationalization (Figure 2.4). Operable crude oil atmospheric distillation capacity declined from 18.62 to 15.66 million barrels per calendar day between January 1981 and January 1985. Petroleum price and allocation decontrol on January 28, 1981, led to the shutdown of small refineries, and the dramatic drop in petroleum product demand between the beginning of 1978 and early 1983 contributed to the shutdown of refineries by small and large refiners (Table 2.12).³⁰ Over the last few years, the industry has witnessed a period of capacity reduction. About 362 thousand barrels per calendar day of crude distillation capacity was mothballed during 1992 and 1993. This most recent period of capacity rationalization occurred at the same time several new environmental regulations were implemented (e.g., Phase II RVP controls, oxygenated gasoline, and low-sulfur diesel fuel). While the connection between refinery closures and the environmental regulations has not been conclusively demonstrated, it should be noted that it is generally the small independent refiners that have shut down (Table 2.12).

Projections of domestic crude oil atmospheric distillation capacity are based on the most recently reported capacities,³¹ corrected according to gasoline production forecasts reported to the EIA in the Refinery Operations Questionnaire. Based on refiner responses to the EIA Refinery Operations Questionnaire, no decline in operable crude oil distillation capacity is expected through the end of 1994.

²⁸ Respondents to the 1992 NPC survey estimated total capital expenditures directly related to reformulated gasoline would total \$3,979 million between 1991 and 1995. National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), p. N255.

²⁹ For a description of refinery capital modifications that may be required to produce reformulated motor gasoline, refer to T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(94/07) (Washington, DC, July 1994), pp. 1-10.

³⁰ Energy Information Administration, *The U.S. Petroleum Industry, Past As Prologue 1970-1992*, DOE/EIA-0572 (Washington, DC, September 1993), pp. 18-20.

³¹ Energy Information Administration, *Petroleum Supply Monthly*, August 1994, DOE/EIA-0109(94/08) (Washington, DC, August 1994).

Figure 2.4. Domestic Crude Oil Operable Atmospheric Distillation Capacity

Table 2.12. Number of Refineries and Operable Crude Oil Atmospheric Distillation Capacity by Size of Refiner
(Thousand Barrels per Calendar Day)

As of January 1 Year	Size of Refiner							
	Less than 10,000 bpd		10,000 to 30,000 bpd		30,000 to 100,000 bpd		Over 100,000 bpd	
	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
1995 (est.)	16	96	24	381	22	977	108	13,700
1994	17	102	25	420	22	977	108	13,535
1990	26	155	31	500	30	1,275	112	13,341
1985	37	185	33	514	31	1,320	118	13,640
1982	63	318	65	1,006	45	1,824	129	14,741

bpd = barrels per day.

Note: Trans-American Refining Co., Norco, Louisiana, 300,000 barrel per day refinery, which never operated, is deleted from capacities reported for January 1, 1990.

Source: Energy Information Administration, *Petroleum Supply Annual 1993*, DOE/EIA-0340(93)/1 (Washington, DC, June 1994), pp.110-113, and earlier issues.

3. RFG Demand Estimates

Overview

This chapter addresses demand for RFG at the pump or consumption. To assess the adequacy of the new supply of RFG (production plus imports) in the Reconciliation Chapter that follows, the seasonal tendency to build primary gasoline stocks is added to consumption to provide a measure of total motor gasoline demand.

When the reformulated gasoline (RFG) program commences at the retail level in January 1995, EIA estimates that demand for all RFG will average 2,519 thousand barrels per day (MBD), representing a total of about 35 percent of the 7,288 MBD of the estimated demand for all types of gasoline during that month. Figure 3.1 provides an overview of demand for RFG in the 9 mandated control areas plus the 14 States and the District of Columbia that have opted into the program by January 1. Figure 3.1 illustrates that the RFG program is concentrated in the Northeast (PADDs IA and IB) and California. The New England States (PADD IA) have the highest ratio of RFG to projected total motor gasoline demand during January 1995.

For purposes of this study, demand/consumption estimates were limited to four gasoline categories: RFG, oxygenated program reformulated gasoline (OPRG), oxygenated, and conventional.³² Easing the concentration in the Northeast is the fact that no more than three of the four gasoline categories are in demand in sub-PADDs IA or IB in January. In fact, sub-PADD IC is the only region that will market all four categories of gasoline in 1995. In Figure 3.1, the four columns in each bar chart depict estimated demand in each sub-PADD for these categories in MBDs, making it easy to compare relative volumes within and across PADDs.

As shown in Table 3.1, EIA estimates the total demand for RFG (including OPRG) for the total United States in January 1995 to be 2,519 MBD. About 70 percent of total RFG demand is in PADDs I and II, with the middle Atlantic States (PADD IB) alone accounting for about 38 percent of total national demand.

The remainder of this chapter addresses the major factors underlying EIA's estimate of RFG demand for January. The reason for the assumptions and values used by EIA in its estimate are discussed and a comparison is made with the results of selected published studies.

³² This represents a simplification of the diversity of gasolines required by this phase of the RFG program. The industry must produce and deliver numerous types of gasoline, with variations in type of oxygenate used (ether or alcohol); different Reid Vapor Pressures (RVPs); and different grades (regular and premium -- midgrade will be terminal-blended). Each of these gasoline types is then blended with different proprietary additives for final delivery. (This proliferation of gasoline types is addressed in the Deliverability Chapter that follows.)

Figure 3.1. Motor Gasoline Demand by Type and Region for January 1995
(Thousand Barrels per Day)

Source: Energy Information Administration estimates.

Table 3.1. Motor Gasoline Demand by Type and Region for January 1995
(Thousand Barrels per Day)

PADD	RFG	OPRG	Total RFG	Oxygenated	Conventional	Total
IA	310	28	338	0	18	356
IB	246	719	965	0	101	1,066
IC	75	53	128	59	1,048	1,235
PADD I	631	800	1,431	59	1,167	2,657
II	341	0	341	77	1,727	2,145
III	247	0	247	36	727	1,010
IV	0	0	0	89	132	221
V (exclude CA)	0	0	0	263	170	433
CA only	500	0	500	324	0	824
Total	1,719	800	2519	848	3,923	7,290

Source: EIA estimates.

Factors Affecting RFG Demand

Baseline Demand for Total Motor Gasoline

Continuing a long-term trend, total demand for motor gasoline is projected to rise from 6,916 MBD in January 1994 to about 7,290 MBD in January 1995. While some of this projected increase of about 400 MBD is the direct result of the RFG program (reduced automobile efficiency), much of it reflects the negative impact the January 1994 cold spell had on driving. Still, more than half of the estimated higher demand is the result of other factors that impact the consumption of all types of motor gasoline.

The demand for all motor gasoline is estimated to increase from prior-year levels because of a continuing increase in personal income available for travel and the assumption of normal winter weather. The resulting increase in vehicle miles travelled is only partially offset by a modest increase in the automobile fuel efficiency, as people retain older, less fuel-efficient cars. The net increased automobile use by far is the most significant factor contributing to the increased motor gasoline demand.

In the short term, the EIA estimate reflects the fact that January historically has the lowest demand, even under normal weather conditions. Meanwhile, the cost of imported crude oil to the refinery is estimated to be \$3.70 higher³³ than January 1994, and total primary motor

³³ Energy Information Administration, *Short-Term Energy Outlook*, Third Quarter, 1994, DOE/EIA-0202 (94/3Q) (Washington, D. C., August, 1994).

gasoline stocks are approximately the same as last year.³⁴ The combined effect of these changes (weather, crude oil price, and stock levels) have only a minor effect on the EIA demand estimate.

Incremental RFG Demand

Spillover

EIA's estimate for RFG demand for January 1995 assumes a spillover rate of 5 percent. During the oxygenated gasoline seasons of 1992-93 and 1993-94, demand for the regulated fuel was higher than that needed to meet consumption in the nonattainment areas alone. Spillover is the term applied to the use of regulated fuel (in this case, RFG) outside nonattainment areas. This increased usage effectively adds to demand for RFG while reducing consumption of non-RFG or conventional gasoline. Spillover is expected to occur with RFG because the geographic regions requiring the new fuel do not exactly correspond to existing gasoline distribution patterns; hence, some fuel from the regulated areas will spillover and be sold in place of conventional gasoline in the nonregulated areas. In certain cases, it may be cheaper to sell RFG at a penalty in a conventional area than to pay the additional transportation to bring non-RFG gasoline from the nearest available terminal. In other cases, companies may be unable to work out exchanges of RFG excess to local demand to obtain lower cost conventional gasoline.³⁵

The average spillover for oxygenated gasoline estimated for the winter of 1993-94, the second year of the program, was approximately 2 percent, about the same as the first year. The industry had sufficient economic incentive to minimize spillover by changing distribution patterns and increasing the use of exchanges among companies. However, implementation of the oxygenated program was simpler by comparison than its RFG counterpart. Regulatory statutes and altered distribution patterns increase the complexity of the RFG program. Although the industry has an economic incentive to minimize spillover of RFG due to incremental delivered product cost, EIA estimates that spillover will average approximately 5 percent *throughout* 1995, because of the complexity of handling increased product segregation requirements and uncertainties surrounding the liability for additives. If lower than estimated spillover rates are experienced, the demand for RFG would drop by approximately 24 MBD for each percent.

Price Elasticity

The EIA estimate assumes a decrease of only 16 MBD in total U.S. demand in response to a anticipated price increase at the pump, reflecting a pass-through of higher RFG production costs.³⁶ Normally, motor gasoline demand is quite inelastic with respect to short-term changes

³⁴ The subject of primary stock levels is addressed in the Reconciliation Chapter that follows.

³⁵ The extent to which the industry has exchange agreements in place by December, in order to facilitate filling secondary storage, has a direct impact on both the amount of RFG demand in January and the capability of the logistics to meet deliverability requirements. (This is discussed further in the Deliverability chapter, that follows.)

³⁶ Refinery plus oxygenated costs are estimated to be 3.9 cents per gallon in the winter and 3.4 cents per gallon in the summer, based on MTBE as the primary oxygenate at prices as of August 1994. T. Lidderdale, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," *Petroleum Marketing Monthly*, DOE/EIA-0380(94108) (Washington, D.C., August, 1994), pp. xiii-xxii.

in retail prices. This was borne out during the oxygenated gasoline seasons of 1992-93 and 1993-94, when pump prices were subject to comparable pass-through cost increases.³⁷

Primary Stock Levels

Barring unforeseen contingencies, EIA expects normal stock levels for all types of gasoline to prevail at the end of the year and into January.³⁸ Differences in PADD-level gasoline primary stock levels are not estimated to have a significant effect on estimated demand when the RFG program begins in January 1995. Lower-than-normal primary stock levels tend to indicate forthcoming product shortages, and the rush to replenish secondary stocks often results in unusually large draws on the primary storage system.

Fuel Efficiency

In its estimate of January 1995 RFG demand, EIA assumes that RFG demand will be increased approximately 1.7 to 2.0 percent, or about 45 MBD, to compensate for lower fuel efficiency. The switch to RFG is expected to cause fuel efficiency to decline slightly because the energy content of RFG is lower than for conventional gasoline. RFG requires at least 2 percent by weight of oxygen to be present, which results in a Btu value lower than the components that are replaced by the oxygenates.

Comparison of Recent Demand Estimates

In addition to the EIA, a number of other organizations have assessed the impacts of the December 1990 Clean Air Act Amendments (CAAA90). These assessments focus on RFG demand, source of supply, and associated cost increases. The following section compares EIA's results with other recent comprehensive assessments from EIA's AEO94, the National Petroleum Council (NPC), Bonner & Moore Associates, DeWitt and Company, and Wright Killen and Company.

A comparison of these refining studies is useful since greater uncertainty about the future may be indicated if the assessments diverge. An examination of the underlying assumptions can provide the basis for some of the differences. Taken together, the results may actually provide reasonable bounds for the forecast assumptions.

Some of these studies addressed a variety of refinery industry issues including capacity additions and utilization, petroleum product imports, production cost increases for reformulated as well as conventional fuels, and spillover of clean product (e.g., RFG) to compliance areas. A few studies were more narrowly focused, such as determining the adequacy of the Renewable Oxygenate Standard (ROS) (DeWitt) or the deliverability of RFG (Wright Killen).

³⁷ C. Dale, J.H. Hackworth, J. Shore., and J. Ostrich, "First Oxygenated Gasoline Season Shakes Out Differently Than Expected," *Oil & Gas Journal*, October 25, 1993, pp. 66-75. Also see Dale, C. "The Second Oxygenated Gasoline Season," *Petroleum Marketing Monthly*, DOE/EIA-0380 (94/06) (Washington, D. C., June, 1994), pp. xiii-xix.

³⁸ Incidents of hoarding at the secondary and tertiary (consumer) level can exacerbate both demand and price. Projecting where, when, and by how much such behavior may occur is outside the scope of EIA's estimate. However, it is a valid concern, and there is a discussion of relevant precedents and preconditions in the Reconciliation Chapter that follows.

Variations in the estimates for RFG demand among these studies appear to be the result primarily of assumptions about (1) spillover, (2) the extent of opt-ins, and (3) seasonality. Clearly, those studies depicting the first few months of the RFG program have lower RFG demand rates than studies providing annual averages because of fewer gasoline sales in the winter months.

Description of Recent RFG Demand Assumptions

EIA Estimate

EIA's RFG demand estimate, described earlier in this section, was based on the assumption that RFG would be demanded in all mandated areas along with all proposed opt-in areas (Table 3.2.). The world oil price, GNP growth rate, weather, fuel efficiency, elasticity of demand, inventories, and vehicle miles traveled all serve as inputs to develop the EIA estimate.

EIA AEO94

EIA used the National Energy Modeling System (NEMS), comprehensive energy modeling system, to produce the *Annual Energy Outlook* (AEO94). EIA assumed a 5 percent spillover and the approval of all areas proposing to opt into the RFG program in preparing the 1994 forecast.

Table 3.2. Assumptions for RFG Demand Estimates

Study	Spillover	Opt-Ins	Geographic Differences ^a	Time Frequency
EIA Market Clearing Estimate	5%	All proposed opt-in areas	None	Annual; Monthly in early 1995
EIA AEO94	5%	All proposed opt-in areas	None	Annual
Bonner & Moore	3%	All proposed opt-in areas	WV included in PADD IB	Annual
DeWitt	Unknown	All proposed opt-in areas	None	Annual
Wright Killen	5-10%	All PADD I opt-ins	PADD I only	Annual

^a From EIA's definitions for PADDs and Sub-PADDs.

Sources: NPC Survey: National Petroleum Council, *U.S. Petroleum Refining* (Washington, DC, August 1993). Bonner & Moore: Bonner & Moore Associates, Inc., *Reformulated Gasoline: Cost, Distribution and Compliance Implications* (Houston, TX, June 1994). EIA AEO94: Energy Information Administration, *Annual Energy Outlook, 1994*, DOE/EIA-0383(94) (Washington, DC, January 1994).

The AEO94 contains forecasts for prices, supply and consumption for oil, natural gas, coal, electricity, and other energy forms through the year 2010. The Petroleum Marketing Module (PMM) of NEMS is used to forecast product prices and supply by region. The PMM uses a detailed linear programming model of a refinery in PADD III, the marginal supplier of domestically produced petroleum products. Forecasts for product prices and supplies for other areas, the United States and abroad, are derived from supply curves developed offline from detailed linear programming models. In developing the forecast, EIA used refinery site and transportation cost increases prepared by the NPC. The Transportation Module of NEMS

forecasts the demand for gasoline based on fuel type, efficiency, the number of drivers, the vehicle miles traveled, and the elasticity of demand. The PMM is solved iteratively with the demand models until supply/demand equilibrium is achieved and product clearing prices are obtained.

National Petroleum Council (NPC)

NPC performs special studies at the request of the Secretary of Energy. Members of the NPC are appointed by the Secretary of Energy and represent all segments of the oil and gas industry. The 1993 *U.S. Petroleum Refining* study performed by the NPC between 1991 and 1993 was a large effort involving 25 oil companies and hundreds of individuals. The NPC used surveys, expert panels, and refinery process modeling to assess the future. This massive study resulted in a thorough quantification of refinery site regulations worldwide, both environmental and safety, along with a cost evaluation for a variety of RFG formulations.

NPC developed the RFG demand estimate before any States opted into the program; hence, the demand estimate is not included in Table 3.3.

Table 3.3. Comparison of 1995 RFG Demand Estimates by PADD (Thousand Barrels per Day)							
Study	IA&B	I	II	III	IV	V	Total
EIA Market Clearing Estimate	1,342	1,473	362	263	0	545	2,643
EIA AEO94	NA	1,436	301	285	0	539	2,561
Bonner & Moore	1,204	1,332	299	228	NA	NA	NC
DeWitt	1,230	1,481	414	251	0	507	2,653
Wright Killen	NA	1,362	NA	NA	NA	NA	NC

NA=Not Available.

NC=Not Comparable.

Sources: Bonner & Moore: Bonner & Moore Associates, Inc., *Reformulated Gasoline: Cost, Distribution and Compliance Implications* (Houston, TX, June 1994). EIA AEO94: Energy Information Administration, *Annual Energy Outlook, 1994*, DOE/EIA-0383(94) (Washington, DC, January 1994).

All of the studies, however, indicate that PADD I, more specifically sub-PADD IA and IB, will account for the largest portion of the RFG consumption. Using the available forecasts, PADD I is expected to demand roughly 55 percent of RFG consumed in the United States, while PADD V is expected to demand 20 percent.

Bonner & Moore

In June 1994, Bonner & Moore released a multi-client study entitled "Reformulated Gasoline: Cost, Distribution and Compliance Implications for PADDs I, II, and III." The study makes full use of Bonner & Moore's refinery process models and transportation models. In developing the estimate for RFG demand, Bonner & Moore assumed a 3 percent spillover rate and delivery of RFG to all proposed opt-in as well as extreme and severe noncompliance areas.

DeWitt

DeWitt presented a paper entitled "Meeting the Renewable Oxygenate Requirement; Possibilities, Problems and Prospects" at the 1994 DeWitt Gasoline-Oxygenate Workshop in August. In calculating the demand assessment, DeWitt assumed all extreme and severe areas would be provided RFG along with all proposed opt-in areas. Spillover was not addressed explicitly.

Wright Killen

Drawing on detailed knowledge of petroleum industry operations, Wright Killen developed a preliminary assessment of RFG supply and demand in PADD I to present informally to EPA. Wright Killen intended for the demand portion of this effort to be compatible with other EPA estimates. In view of this, it is reasonable to assume that Wright Killen used a 5 to 10 percent spillover rate to regions other than the extreme and severe noncompliance areas.

Comparison of the RFG Demand Estimates

In order to compare the estimates, it is necessary to convert EIA's January estimate into an average for the entire year. Since January gasoline consumption is lower than the annual average due to seasonal factors, the equivalent EIA demand estimate for all of 1995 is higher -- 2,643 MBD compared to 2,519 MBD RFG consumption in January. This annualized EIA estimate and the DeWitt study are the two highest forecasts for RFG demand (Table 3.3). The EIA estimate includes the upward trend for motor gasoline demand, which has been evident over the past 10 years.²

4. RFG Deliverability

Overview

A number of modes are used to transport gasoline to consumers. Gasoline can be delivered by pipeline, waterborne tanker and barges, rail, and tanker truck. Storage is required at various points in the distribution system in order to smooth gasoline deliveries.

The new RFG regulations have repercussions on distribution and storage. Refiners, transporters, bulk storage terminal operators, and marketers must segregate RFG batches and assure its integrity by repeated testing as the batch moves from the refiner to the consumer. The RFG regulations also require paperwork to identify each batch of RFG produced.

The picture is further complicated by the delivery of ethanol. New transportation links between the Midwest and the Northeast to deliver ethanol from the production region to the mandated consumption region need to be established.

This chapter details the operational changes in the distribution and storage system mandated by the RFG and ROS regulations. To accomplish this, historical product flows are reviewed. The impacts of the RFG/ROS regulations on each segment of the delivery system -- storage terminals, pipelines, marine, rail, tanker truck, and marketing -- are then reviewed in turn after first assessing the impacts of the regulations that cross-cut all segments of the delivery system. The build-up of RFG stocks required to assure a smooth transition is quantified in the storage section of this chapter. Information from the regulations, the trade press, EIA's ongoing surveys and recent RFG survey was used to develop the assessments in the following sections.

The appendices (Volume 2, Appendices E, J, and K) associated with this chapter provide a comprehensive description of the RFG/ROS testing and documentation regulations, an overview of pipeline and bulk terminal operations, and an assessment of tanker and barge availability.

RFG/ROS Regulations that Impact All Segments of the Delivery System

Multiplicity of Gasoline Types

As states move to comply with the Clean Air Act, the nation has become a checkerboard of areas requiring different types of gasoline at varying times of the year. Federally mandated and opt-in RFG areas are primarily located in the Northeast and Mid-Atlantic states and in Southern California. Other areas include Chicago, Milwaukee and Houston. In many instances, they merge with or are superimposed on areas that have other types of controls (Table 4.1). **The shaded boxes indicate the gasolines used during the year, a ? indicates uncertainty.**

Table 4.1. PADD-level Fuel Requirements in 1995 and Beyond^a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PADD I^b												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP ^c												
PADD II												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP ^d												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi) ^e					?	?	?	?	?			
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP ^f					?	?	?	?	?			

See notes at the end of the table.

Table 4.1. PADD-level Fuel Requirements in 1995 and Beyond^a (Continued)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PADD III												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP ^a					?	?	?	?	?			
PADD IV												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP												

See notes at the end of the table.

Table 4.1. PADD-level Fuel Requirements in 1995 and Beyond^a (Continued)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PADD V												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG ^h												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP ⁱ												
PADD IA												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP												

See notes at the end of the table.

Table 4.1. PADD-level Fuel Requirements In 1995 and Beyond^a (Continued)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PADD IB												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP												
PADD IC												
Conventional Unrestr. RVP												
Conventional OxyFuel												
Conventional 9.0 psi RVP												
Conventional 7.8 psi RVP												
RFG non-VOC controlled												
OPRG												
RFG VOC-1 (RVP ≈ 7.2 psi)												
RFG VOC-2 (RVP ≈ 8.1 psi)												
SPECIAL RVP ^l												

^a The gasoline types displayed on these tables are expected to be available in regular, premium, and mid-grades. Gasohol is not displayed outside its use in the winter oxygenated fuel program. Summer RVP restrictions are effective on June 1 at the retail level but on May 1 at the terminal level, the tables reflect the May date. The question mark (?) designates uncertainty.

^b Sub-PADDs are displayed in separate tables after the listing for PADD V.

^c Atlanta, Georgia, will require 7.0 psi RVP at the retail pump beginning June 1, 1995, based on State legislative action. A 1.0 psi RVP waiver for ethanol blends is allowed. Unlike Federal RVP regulations, Georgia does not require that the controlled-RVP fuels be at terminals by May 1. EPA had not ruled on the RVP requirement as of August 1994. (Conversation with Georgia Department of Environmental Protection, August 1994.)

^d Knoxville, Tennessee, is a "southern-tier" area that has been redesignated as ozone attainment. EPA has approved its request to revert from 7.8 psi RVP to 9.0 psi RVP. Louisville, Kentucky, and its Indiana suburbs will receive low RVP gasoline as well.

^e St. Louis, Missouri, and East St. Louis, Illinois, are considering opting-into the RFG program. It is also considering restricting the RVP of gasoline as a means of achieving the primary National Ambient Air Quality Standard for ozone. State regulations contain provisions for RVP controls as of August 1994. (Conversation with Missouri Department of Natural Resources.)

^f St. Louis, Missouri, is considering a reduced summer RVP requirement as a long-term strategy of abating ozone pollution. No final decision had been made by the State as of August 1994 as to whether RVP controls, or opting into the RFG program, would be the legislated strategy to ozone attainment status. Missouri required that St. Louis motor gasoline have a maximum RVP of 7.2 psi from June 1 through September 30, 1994 and is in the final stages of requiring 7.0 psi RVP fuels from June 1 through September 30 in 1995 and beyond. Fuel suppliers will be given the option of supplying RFG with 7.2 psi RVP during the summer season as an acceptable alternative to 7.0 psi RVP conventional gasoline. EPA had not ruled on the approval of this approach as of August 1994. (Conversation with Missouri Department of Natural Resources, August 1994.)

Several ozone nonattainment areas in Michigan have elected to use restricted RVP gasolines (7.8 psi RVP) as a strategy to achieve ozone attainment. Low RVP gasolines will be required at the retail outlet in Michigan from June 1 through September 15. Reduced RVP fuels are not required until the summer of 1996. (Conversation with Michigan Department of Natural Resources, August 1994.)

^g El Paso, Texas, is expected to gain EPA approval for restricting the RVP of summer gasoline to 7.0 psi. (Conversation with EPA Region 6)

^h Los Angeles and San Diego, California are in nonattainment for both ozone and carbon monoxide. The California SIP for carbon monoxide requires the oxygen content of oxygenated gasoline to be between 1.8 and 2.2 percent by weight. The Federal requirement is 2.7 percent by weight. The US EPA has not yet ruled on the California oxygenated fuels waiver as of August 1994. EPA action will determine whether OPRG differs significantly from California Phase 2 RFG. (Conversation with California Air Resources Board.)

ⁱ Phoenix, Arizona, is required by State law to dispense gasoline that has a maximum RVP of 9.0 psi from October through May (without an ethanol waiver) and 7.0 psi from June 1 through September 30 beginning in 1995. (Conversation with Arizona Department of Environmental Quality.)

^j See note c, above.

Sources: Environmental Protection Agency (EPA), "Standards for Gasoline Volatility," *Federal Register*, December 12, 1991, p. 64704-64713; "Standards for Reformulated and Conventional Gasoline," *Federal Register*, February 16, 1994, p. 7716-7878; *Reformulated Gasoline and Anti-Dumping Questions and Answers*, July 1, 1994; Technical Corrections, "Standards for Reformulated and Conventional Gasoline," *Federal Register*, July 20, 1994, p. 36944-36969; and telephone conversations with regional and national EPA offices, unless specifically noted.

In addition, some areas, such as Atlanta, have opted to utilize other strategies such as low-RVP gasolines to achieve ozone compliance. Low-RVP gasoline is less volatile, and therefore, less polluting.

As a result, PADD I, mainly the East Coast, needs nine types of RFG and conventional gasoline at different times of the year. PADD II, the Midwest, requires six types, as does PADD III, which constitutes basically the Gulf Coast. Each of these regions also has one other type pending adoption. PADD IV, the Rocky Mountain area, needs four gasolines, and PADD V, the West Coast, currently requires seven different types. This region, however, will see further change in 1996 when California's unique more stringent program goes into effect. Table 4.1 illustrates the variety of gasolines required in each of these areas. It does not include the octane grades associated with each type.

Consequently, the addition of RFG gasolines to the product distribution system will once again increase the complexity of its operations. The new RFGs with their various grades will exert increased pressure on a system that has had to accommodate previous expansions in the number of products mandated by environmental regulations, i.e., oxygenated gasoline for carbon monoxide reduction, reduced RVP gasoline for VOC control, and the low-sulfur diesel fuel requirement which went into effect on October 1, 1993.

The majority of gasoline in the United States is moved to market via the product pipeline systems which operate throughout the country. The efficiency of pipeline operations is predicated on moving large volumes of fungible products. As segregated products enter the system, more interfaces and transmixes (off-spec product created between batches during transport) are created and often a more valuable, clean product is blended-down into a less valuable class of product. This was the case with low-sulfur diesel when it was first introduced to the pipeline system in October 1993. Cuts were made much earlier in the pipeline stream to protect the integrity of the mandated product, a practice that will be extended to RFG.

For example, Colonial Pipeline, the largest product pipeline in the nation, will significantly increase the grades of gasoline it ships. Currently, Colonial ships 41 different grades of gasoline. With the initiation of the RFG program a new coding system will be put into effect covering all the variations in gasoline formulations. Colonial will then have 147 codes. If all products were to move on a segregated basis rather than in fungible batches that number would escalate to 269. However, Colonial expects to receive nominations for less than 50 different types of RFG.

The proliferation of products not only affects pipelines but also marine operations and terminals downstream from the refinery. Increased storage capacity will be required in many instances to handle all the various gasoline formulations and other light products in the pipeline and tank farm systems. Such storage may not be available during the initial stages of the RFG program, and, in many cases, may be difficult or impossible to construct because of local ordinances and costs.

Fungibility

The RFG regulations will have a definite impact on the fungibility of gasoline. Simple Model RFG is fungible and can be commingled with other RFGs produced using the Simple Model. But, gasoline produced in accordance with the Complex Model cannot be commingled with gasoline produced using the Simple Model.

RFG produced to meet the per gallon compliance is fungible and may be mixed with RFG produced to meet the averaging compliance standard. However, before January 1, 1998 Complex Model produced RFG is not fungible and must be segregated and tracked at all times from the refinery through the entire distribution system to retail outlet.

RBOB is fungible to the extent that the type and amount of oxygenate to be blended are the same. At the 2 percent oxygenate level, RBOBs produced for blending with ethers by different refiners are fungible while RBOBs produced for ethanol blending are fungible with other such RBOBs.

However, RBOBs manufactured for ethanol blending are not fungible with RBOBs produced for ether blending during the high ozone season. Moreover, should a refiner produce an RBOB and designate it to be specifically blended with a specified oxygenate, it must be segregated and is excluded from commingling with other RBOBs.

Refiners have tried to offset some of the loss of fungibility by opting to use the Simple Model to manufacture RFG. Simple Model RFG is fungible whereas Complex Model RFG is not. Those refining respondents to EIA's survey that will produce RFG have unanimously chosen the simple model. It will occupy this prominent position until January 1, 1998, when the Simple Model will no longer be authorized in formulating RFG, and all RFG must be produced using the Complex Model.

Exchange Agreements Problems

The EIA industry survey has revealed that many companies will in fact have to renegotiate, reevaluate or cancel their current exchange agreements because of the RFG regulations. The effects of these developments cannot be assessed at this time.

Exchange agreements abound in the industry. They are contracts between companies to have one provide and deliver product to the other in a different geographic locality where logistics do not lend themselves to easy access by one of the parties. They usually have price differentials to cover differences in product upgrading and transportation costs. Their use adds efficiency to the distribution system. Reformulated gasoline introduces a new quality (and price) differential when RFG must be exchanged for conventional or oxygenated gasoline. The ROS rule adds to the complexity in that the type of oxygenate in RFG becomes an additional variable in the contract.

The RFG program also presents certain unique problems for exchange agreements. Additional record-keeping and reporting requirements and decreased flexibility to correct problems in the field all may mitigate against such agreements and subsequently reduce the volume of gasoline exchanged between refiners. Such a reduction would have to be offset by an increase in spot market volumes to maintain a balanced distribution system. As a result, refiners may realize higher contracting costs, and may experience greater price instability for a portion of their supplies. There is a remote possibility that market inefficiencies may contribute to temporary supply disruptions.

Testing and Documentation

The RFG program imposes extensive testing and documentation throughout the production and distribution system. In addition, developing and transferring the necessary paperwork may also delay delivery. An overview of the "Regulatory Paperwork Flow and RFG Testing and Documentation" is provided in Appendix D.

Storage

Storage is required for transportation and distribution activities. A characterization of storage operations is provided in Appendix E. The impacts of the RFG/ROS rules follow.

Operations

As a result of the RFG regulations, some terminal operators (both pipeline and other terminals) are cutting back to one tank per product, which constrains the operator's ability to provide all the products requested by their customers. Having one tank per product at a terminal increases odds of running out. Even after going to one tank per product, some terminals are having to limit the products they will supply to their customers. Some terminals will specialize in a set of products and arrange exchanges. However, terminal specialization means product is available from fewer places. If product is available from fewer locations, trucks must travel longer to pick up and deliver to retail stations, and if product runs low at one terminal, fewer other terminals will be available to make up the shortfall. The result is an increased risk of local product shortfall.

In the longer term, the industry will probably build additional storage as required to relieve serious bottlenecks; however, construction may be restricted in certain areas like California. Regardless, relief storage is not available this winter, and at this time, where all the chronic bottlenecks requiring new capacity will occur is uncertain.

At terminals that do not have to change tanks to new products very often, turnovers are being made now to prepare for the RFG program. While these terminals will be ready for December 1, 1994, as 1995 progresses, subsequent turnover needs may become a supply issue. Seasonal turnover occurs from winter to summer in which some customers want to switch from RBOB to RFG. Because RBOB cannot be mixed with RFG and be sold as RFG, if the RBOB tank cannot be drained dry, presumably the shippers would have to flush RFG through the tank (selling the mixture with conventional gasoline at a loss), until the tank tested clean for RFG. Some tanks require weeks of time to accomplish such a turnover. EPA is considering issues raised by industry such as this and reasonable accommodations that deal with tank bottoms in cases where drain-dry tanks are not available.

Buildup of RFG Stocks

In order to assure a smooth transition to RFG, the industry needs to build and maintain a stockpile of RFG. Assuming the RFG stock build is in line with historical patterns, total U.S. stocks of RFG, including RBOB, are estimated to be 53 million barrels (MMB) at the primary level on December 31, 1994. This stock level provides just over 20 days of supply based on forecast demand for RFG of 2,519 MBD in January 1995. Based on the days of supply, RFG will be lower than the normal 27 days of supply for total finished motor gasoline in January. The Lower days of supply for RFG can be attributed to the following factors:

- Demand for RFG is concentrated in PADDs I, II, and V, where days of supply tend to be lower than the national average. Normal levels are: PADD I, 24 days; PADD II, 23 days; and PADD V, 21 days.
- The December 31, 1994 stocks reflect stock build activity during the RFG transition period. Historical experience with stock build activity during the introduction of new fuels (e.g. low sulfur distillate fuel oil) indicates that stocks do not reach normal levels until after the transition is complete.

While RFG stocks are forecast to be somewhat lower than normal based on days of supply, they should be adequate to maintain supplies in most areas.

Given that September 1994 RFG stocks are zero, the RFG stock build during the period from October-December 1994 is expected to average 571 MBD. During the early part of this stock build, much of the RFG volume supplied will be used to flush conventional gasoline out of the primary and secondary petroleum supply and distribution systems. The RFG volume used in flushing will be downgraded to conventional gasoline through mixing and will be sold as such to end users. Most RFG stock building activity in the primary system is expected to take place in November 1994, when the rate is expected to average 848 MBD. The rate of additions to primary RFG stocks is expected to decrease to 363 MBD in December as RFG begins moving to secondary storage.

The stock build for January is estimated at about 96 MBD or approximately 4 percent of forecasted RFG demand. Total finished gasoline stock builds for January averaged approximately 6 percent of demand from 1990-1994. By this measure, the RFG stock build is lower than normal. The expected RFG stock build may be reduced or even changed to a stock draw in the event of a surge in demand or a disruption in supply (see chapter 5 on Supply Demand Reconciliation). While a lower stock build could be accommodated in the short term, the normal build up of gasoline stocks to meet spring and summer demand could be delayed.

The RFG surveys conducted for this study, including the "Reformulated Gasoline Study Bulk Terminal Operations Questionnaire," requested that respondents provide forecasted month-end stock levels for October 1994 through January 1995. Most respondents were unable to provide these forecasts. To overcome this limitation, EIA developed estimates of RFG stocks using three separate methods. Estimates of RFG stocks produced by each of the three methods were essentially consistent allowing for reasonable levels of uncertainty. Methods used in estimating RFG stocks are summarized below.

- **Oxygenated Gasoline New Supply Method** - This method was based on the assumption that the percentage of RFG new supply added to inventory would be similar to the percentage of oxygenated gasoline new supplies added to inventories during the oxygenated gasoline stock build of 1993. This approach made use of survey data showing RFG new supply (refinery production and imports). Stock builds were estimated as the product of RFG new supply and a ratio calculated by dividing oxygenated gasoline stock change by oxygenated gasoline new supply. Stock estimates at the PADD level were produced by allocating U.S. stocks to districts based on the percent of RFG demand in each district.

- **Low Sulfur Diesel Stock Build Method** - This method was based on the assumption that the build-up of RFG would follow a pattern similar to the build-up of low sulfur diesel fuel oil stocks. This approach was developed to provide an independent verification of the end-of-month stock levels calculated from survey data. Considering the number of market disruptions during the start of the low sulfur diesel season, these numbers are expected to represent minimum requirements for the RFG program.
- **Market Clearing Method** - EIA used the survey data and the demand forecasts, as well as historical data on gasoline movements between PADD, for each gasoline type to arrive at estimated stock changes. RFG supply analyses and the reconciliation of RFG supply and demand for January 1995 in the next chapter have been performed based on estimates from this method.

The resulting estimates for each method are shown in Table 4.2.

Pipelines

Product pipelines start as large diameter pipelines from refining and harbor areas and become smaller in diameter as they arrive at storage terminals and other end-user facilities. Products move through the system at a rate ranging from three to eight miles per hour, depending upon the diameter of the pipeline and the pressure, as well as the density and viscosity of the product. Accordingly, petroleum products traveling in lines from Houston, Texas, will arrive in the New York City area within 14 to 22 days (Table 4.3).³⁹ A detailed discussion of pipeline operations is provided in Volume 2, Appendix F.

A number of pipelines will move product more slowly through their systems, thereby diminishing their capacities as a result of the increased segregation requirements coupled with the increased number of products that must be segregated. Eleven pipelines responding to EIA's "Reformulated Gasoline Study-Product Pipeline Operations Questionnaire" indicated they would experience such degradation. Four of the 11 indicated declines in product movement (as measured in thousands of barrels per day) of from 1 to 10 percent. Generally, newer pipelines seem to have fewer problems dealing with the regulations since their equipment is better able to deal with greater segregation. For example, newer breakout tanks are designed to be completely emptied and turned around in several hours.

Problems are anticipated for smaller pipeline spurs. For example, product segregation requirements can cause a small pipeline problems if a shipper has been too slow to move a product out of a tank needed for a new batch. With limited tankage, use of tanks is timed to allow the most efficient use of storage. Without a place to put the product, a small pipeline will shutdown until the tank is available.

³⁹National Petroleum Council, *Petroleum Storage & Transportation*, Volume V, 1989 p. 45.

Table 4.2. Comparison of RFG Stock Estimates by Method (Including RFG, OPRG and RBOB)

(Thousand Barrels, End of Month)

PADD	Method	Oct-94	Nov-94	Dec-94	Jan-95
I	Oxy-Gas New Supply	8,999	23,445	29,850	31,747
	Low Sulfur Diesel	4,740	19,380	25,640	27,350
	Market Clearing	NA	NA	NA	31,524
IA	Oxy-Gas New Supply	2,127	5,540	7,053	7,502
	Low Sulfur Diesel	NA	NA	NA	NA
	Market Clearing	NA	NA	NA	7,456
IB	Oxy-Gas New Supply	6,068	15,808	20,127	21,406
	Low Sulfur Diesel	NA	NA	NA	NA
	Market Clearing	NA	NA	NA	21,243
IC	Oxy-Gas New Supply	805	2,097	2,670	2,839
	Low Sulfur Diesel	NA	NA	NA	NA
	Market Clearing	NA	NA	NA	2,794
II	Oxy-Gas New Supply	2,147	5,594	7,122	7,575
	Low Sulfur Diesel	1,350	5,400	6,930	7,480
	Market Clearing	NA	NA	NA	7,494
III	Oxy-Gas New Supply	1,551	4,041	5,145	5,472
	Low Sulfur Diesel	NA*	NA*	NA*	NA*
	Market Clearing	NA	NA	NA	5,455
V	Oxy-Gas New Supply	3,146	8,196	10,435	11,098
	Low Sulfur Diesel	1,850	7,650	10,300	11,620
	Market Clearing	NA	NA	NA	11,055
U.S.	Oxy-Gas New Supply	15,844	41,277	52,552	55,892
	Low Sulfur Diesel	9,960	40,490	53,470	57,150
	Market Clearing	NA	NA	NA	55,528

NA=Not Available

* Not observable since stocks levels not driven by demand in this PADD.

Notes: • Totals may not equal sum of components due to independent rounding. • Stocks of RFG in PAD District IV are expected to be zero. • January 1995 stock estimates using the market clearing method were derived by adding January stock changes to December ending stocks from the oxygenated gasoline new supply method. The stock changes used were as follows in thousand barrels: PADD I = 1,674; PADD IA = 403; PADD IB = 1,116; PADD IC = 124; PADD II = 372; PADD III = 310; PADD V = 620; U.S. Total = 2,976. • Market clearing estimates based on December ending stocks from the low sulfur diesel method simply apply the stock changes to the December stocks derived using that method.

Source: EIA estimates.

Table 4.3 Comparison of Product Movements
(Days to Deliver)

	Pipeline	Tanker	Barge
Houston to New York	19	5	7
Houston to Chicago	18	N/A	8
Houston to Pittsburgh	18	N/A	8

Source: EIA estimates.

An unknown for all pipelines at the time of this report is the amount and number of RBOB's that might be nominated. RBOB's can increase the number of product segregation requirements substantially. Some pipelines have indicated that to some extent, the geographic concentration of RFG areas (including opt-ins) would help reduce the number of segregated products they would have to handle at any one time. For example, it is likely that only RFG will flow from the Gulf to the Northeast.

Re-refiners who traditionally processed transmix and sold it into the local market may not be able to produce RFG, and may have to ship their conventional product to new market areas. These same re-refiners may still not know who will buy their product. In some cases, shippers who never had to deal with transmix before because a pipeline blended it back into the products will now have to take transmix off the pipeline, since it cannot be blended into RFG. These shippers will have to find storage and purchasers for this transmix if they cannot re-refine it themselves.

Marine

Maritime transporters responded to EIA's "Reformulated Gasoline Study Tanker/Barge Operations Questionnaire" survey of August 1994. According to the answers, the industry foresees increased costs due to cleaning of contaminants and segregation of product shipments. Increased cleaning will cause out of service time for barges which can be compounded by missed tides.

Another RFG-related issue is the availability of U.S. flag tankers to carry product between PADD III and I, particularly during a supply shortage. U.S. flag tankers are also needed to carry surplus conventional gasoline from PADD IB to IC. An analysis of the availability of U.S. flag ships is contained in Appendix G.

Tanker Trucks

Tanker trucks typically provide the final stage of delivery to retail outlets or end users with on-site storage. Additionally, trucks may be used for intermediate transportation between a refinery or terminal and a wholesale storage location, commonly called a bulk plant. Distances covered can range from less than a mile, for local deliveries, to hundreds of miles to remote locations, particularly in the western United States.

The equipment used in this service is typically a tractor-trailer combination, with a single trailer carrying 8,000 to 10,000 gallons of product. Where allowed, double trailers may be used, increasing truckload size to as much as 12,000 gallons. The trailer is usually divided into several compartments, in sizes ranging from several hundred to several thousand gallons each. Compartments in modern trailers are designed to drain dry, leaving no significant residual product in the truck. In some situations, typically small short-haul deliveries, a single truck called a tankwagon or bobtail is used, capable of metering small quantities into storage tanks.

Truck Operations

Trucks used in petroleum delivery may be operated by the supplier of the product, the customer taking delivery, or a common carrier employed by either. Transportation is paid for by the buyer, in the case of terminal, or "rack" sales, or by the seller, in the case of delivered ("tankwagon") pricing. Title to the product during transport is typically held by the party paying for delivery.

Trucks are filled at loading facilities, called racks, located at refineries, pipeline or water terminals, or bulk plants. Typical terminal loading equipment is automated, and individually fills each compartment of the truck to its capacity with a given product, recording the volume loaded on a bill of lading. Separate compartments of the truck are often filled with different products, according to customer needs. Additives, including oxygenates, may be added to the loading stream by automated equipment, or separately placed in the truck compartment. In the latter case, mixing of the product and additive is accomplished by the motion of the truck between origin and destination, called "splash blending."

At destination, product may be delivered and measured by various means. In the case of underground tanks, delivery is made by "gravity drop," where a compartment is allowed to drain through a length of hose directly into the destination tank. For aboveground tanks, a truck-mounted pump is used, also typically draining each compartment. In either case, the delivery amount is usually assumed to be the amount loaded into the compartment, which is sometimes sealed at loading to prevent tampering. In tankwagon deliveries, a meter attached to the truck-mounted pump determines the amount of product delivered. Regardless of delivery method, the quantity of product in the destination tank is often measured before and after unloading, in order to confirm the quantity delivered.

Truck RFG Issues

- **Differentiation between areas using RFG versus conventional gasoline, and some terminals not offering both products, could require trucks to travel longer distances, on average, to obtain and deliver gasoline.** This is likely to increase costs to marketers and, eventually, consumers.
- **The increased burden on the trucking sector from longer delivery distances if combined with the need for ethanol transport, is likely to reduce flexibility for response to high trucking demand situations, such as supply bottlenecks or cold snaps.** While in the long run, trucking capacity may grow in response to this stimulus, the reduction in the flexibility to be able to pull gasoline from a greater number of available supply sources is likely to be permanent.
- **Splash-blending of oxygenates, particularly ethanol, in trucks may significantly increase costs in many areas.** Ethanol splash-blending is commonly performed today, and will almost certainly increase due to the ROS. The prescribed handling, testing, and documentation procedures would represent a significant increase in burden and cost to truck owners and operators. Additionally, the potential liability of truckers for off-specification product would likely result in additional cost increases.

Marketing

In terms of product deliverability, the impact of the RFG program on the marketing sector of the petroleum industry is lessened by relative lack of choice. Retail marketers will, for the most part, have little discretion in the selection of product due to legally prescribed control areas, and production and logistical impacts will have largely occurred upstream. However, the operation of storage tanks at retail outlets and bulk plants presents difficulties similar to those at terminals, including testing, documentation, and potential liability. (This report addresses the marketing function only in terms of logistics. Other important issues, such as pricing, are beyond the scope of this report.)

Wholesale Operations

Gasoline marketing in the United States occurs through a number of different channels, involving different numbers of steps in the distribution chain between the refiner or importer and the final consumer. A portion of the gasoline purchased by consumers at retail outlets, or filling stations, and much of that delivered to end users having their own on-site storage tanks, first passes through a wholesale storage and distribution facility called a bulk plant. A bulk plant has both loading and unloading facilities, and typically has tens of thousands of gallons of storage, often above-ground. Many bulk plants were originally built by refiners to serve local distribution needs, but most are now owned by independent distributors (also known as jobbers or marketers). While bulk plants once served to break down truckload shipments of gasoline into smaller tankwagon deliveries, the proliferation of larger-volume retail outlets now makes it possible to supply most outlets directly from the terminal, bypassing the bulk plant. However, many deliveries to commercial, industrial, and agricultural accounts are still made through these facilities. Some distributors also utilize bulk plants for blending of oxygenates, particularly ethanol, into gasoline.

Retail Outlets

Retail gasoline outlets may be owned by refiners, distributors, dealers, or outside interests, and operated by employees of the owner, or by other individuals on a lease, commission, or consignment basis. Outlets may be branded, purchasing from a refiner or large marketer and selling under its name, or unbranded, purchasing from suppliers of its choosing. These facilities typically have two or more pumps, and storage tanks, usually underground, holding 10,000 gallons or more of gasoline or other products. Sales volumes may range from hundreds to hundreds of thousands of gallons per month. In recent decades, the number of outlets has declined, and volume per outlet has grown, as economies of scale have favored high-volume locations on major traffic thoroughfares. Many older traditional "service stations" have been converted to other uses. Over the past few years, environmental legislation has required the replacement of many underground storage tanks, accelerating the upgrading of favorable locations and the shutdown of lower-volume outlets. Unattended, automated stations, known as cardlocks, have recently gained broader acceptance, especially catering to commercial fleet accounts.

Seven refiners responded to EIA's inquiry regarding changes in marketing areas. Four indicated they would withdraw from several areas because they could not supply RFG. The combined volumes in the areas affected were 16,840 b/d. One indicated problems with low-RVP gasoline which might affect deliveries of 4,000 b/d in the Southeast while another stated that ROS would create potential obstacles in supplying a Mid-Atlantic market. Another stated that volumes of all gasolines would have to be reduced by 2,000 b/d in a Southwest market. Overall the volumes cited are not particularly large and could potentially be made up by other refiners.

RFG Issues

- **Product choice for marketing operations will be largely determined by legal mandate or logistical advantage.** In non-control areas, expected cost differences are likely to favor conventional gasoline, except where offset by higher transportation costs. Oxygenate choices will presumably be made by refiners, importers, and blenders, with marketers' preferences influenced by relative costs and consumer acceptance.
- **"Turnover" of retail storage tanks between different types of gasoline may cause some difficulties, especially for outlets with small sales volumes.** During initial transition to RFG, and seasonal changeover between VOC-controlled and non-VOC-controlled products, tanks will have to be "flushed" with several loads of the new product, then tested to meet specifications.
- **Off-specification product found in retail tanks will have to be removed and replaced.** Unlike terminals, where off-specification product could be rebled or shipped to a non-RFG area, as appropriate, gasoline in a retail tank not meeting RFG specifications would have to be pumped out and likely taken elsewhere and rebled or downgraded. The tank would then be refilled with new product and retested before use.
- **Service of a single tank by multiple suppliers may complicate liability for off-specification product.** Multiple suppliers to an outlet, a common occurrence in unbranded marketing, would presumably each be liable for product found in a tank to which they had made any recent deliveries.

Ethanol Deliverability

Following release of the RFG regulations, EPA issued the Renewable Oxygenate Standard (ROS) mandating renewable oxygenates for the RFG market. Originally set at 30 percent, EPA decided to phase in the use at 15 percent for the 1995 season and then move to the full 30 percent during the second year of the RFG program. Individual refineries are responsible for achieving this result, but can average it over the entire year.

In reality, the ROS requirement can only be satisfied at this time by using ethanol and ethyl tertiary butyl ether (ETBE) which is derived from ethanol. While ETBE, an ether, can be blended into gasoline at the refinery and shipped via pipeline, there is currently far too little

production capacity to manufacture the volumes needed to be of assistance in meeting the 15 percent ROS requirement in 1995. In fact, due to certain other economic and health reasons, it is doubtful that ETBE will be produced in sufficient quantities for the 1996 season.

Ethanol, an alcohol, on the other hand, has certain properties that preclude its transportation by pipeline. It has an affinity for water which later may separate out in tank bottoms or fuel lines etc. Although there is a trading provision for renewable credits in the regulation, such a system is as yet undeveloped, thus ethanol blending emerges as the sole compliance vehicle for the ROS.

However, its use during the ozone season, defined as April 1 to September 15, tends to increase VOCs, and direct ethanol blending for that time period is discouraged by withholding renewable credits. Consequently, wintertime ethanol blending offers the only viable path to ROS compliance.

Nevertheless, there are real concerns regarding ethanol's availability in the dominant RFG areas of the Northeast and Southern California. Ethanol is primarily produced in the Midwest, and its use as a fuel extender has been concentrated in that area. Industry personnel in the dominant RFG areas have had little experience in dealing with ethanol. Consequently, logistics for moving it to those destinations and storage located there to handle ethanol are limited. In addition, retail outlets may require additional preparation prior to receiving fuel containing ethanol because of water affinity problems, and there have been some indications of customer resistance to the product in the RFG areas.

No evidence surfaced in the EIA survey that indicated that ROS will stop the RFG program from getting under way in December and January. Since the ROS increases the segregation requirements, which further diminishes flexibility in the delivery system, chances of unpredictable local spot shortages are increased. (See the discussion of findings under Pipeline and Bulk Terminal deliverability.) Beyond January, the industry may have a difficult time meeting the ROS for the year due to the fact that ethanol credits can only be earned during approximately half the year, and due to the infrastructure changes that must occur in the Northeast, which will result in a slow start-up period.

Operating with Ethanol

- **The 1995 ROS requirement is likely to be met almost entirely by ethanol.** The ROS requires that 15 percent of the volume of RFG produced use renewable oxygenates in 1995. The two major renewable oxygenates that would be used to satisfy this requirement are the alcohol, ethanol, and the ether, ETBE, which is similar to MTBE, but uses ethanol rather than methanol in its production. (Ethanol in the United States is produced primarily from corn.) In 1995, however, very little ETBE capacity will be available, so ethanol will have to be used to meet the 15 percent requirement.
- **Ethanol has physical characteristics that impact deliverability such as its affinity to water.** Ethanol requires use of different materials in delivery and storage facilities than other petroleum products require, particularly the materials used in seals, gaskets, and tank liners.

- **Deliverability of ethanol under the ROS will be affected by seasonal swings in use that are required as a result of volatility concerns.** Ethanol increases the volatility of gasoline when used in quantities such as required for gasohol, oxygenated gasoline or RFG. EPA refers to the increase in gasoline volatility that occurs when ethanol is added as "commingling-related volatility." In order to assure that the ROS does not jeopardize the VOC benefits of the RFG program during the summer months (high ozone season)⁴⁰, EPA does not allow ethanol or any other renewable oxygenate that exhibits commingling-related volatility to receive ROS credit during the high ozone season. Thus, since ethanol is essentially the only available renewable oxygenate in 1995, the 15 percent annual ROS requirement must be met during non-VOC controlled season, which for producers encompasses about 6.5 months.⁴¹ (Ethers do not exhibit this commingling effect, so when ETBE becomes available, it can be used during the summer months and receive credit towards meeting the ROS requirements.)
- **The major RFG demand area is in the Northeast (PADDs IA and IB), an area that does not currently use much ethanol. Delivery and storage infrastructure changes will have to occur in the Northeast to meet the ROS requirement in 1995.** The Northeast historically has not used much ethanol. For example, the Federal Highway Administration reported 1992 gasohol sales in PADDs IA and IB of about 3.3 MBPD.⁴² Assuming this gasohol used 10 percent ethanol, less than 1 MBPD (365 thousand barrels per year) of ethanol was required. Using EIA demand estimates for PADDs IA and IB, about 13.2 MBPD (4,839 thousand barrels per year) of ethanol will be needed during the year to meet the 1995 ROS requirement.⁴³

The infrastructure problem is magnified by the fact that the 4,839 thousand barrels cannot be spread over the year. They must be used during approximately a 6-month window. That is, if no credit trading is considered, the delivery system must be able to handle 26.4 MBPD during half the year instead of the 13.2 MBPD annual average.

Infrastructure changes take time. For example, ethanol cannot be stored in existing petroleum product tanks without some changes to accommodate ethanol's incompatibility with seals, gaskets and tank liners used in petroleum product facilities and changes to prevent water infiltration. In addition, blending facilities also usually need to be altered to deal with ethanol. One source⁴⁴ indicated that converting a tank and the piping to a

⁴⁰The final rule under "Renewables Requirement and Definitions," (III, C) indicates that while an ethanol-gasoline mixture can be produced that meets the high-ozone season RVP standards, the energy required for this additional processing negates the fossil energy savings from ethanol.

⁴¹The summer VOC-controlled season from May 1 through September 15 requires that controlled RFG be in place at terminals dispensing such product by May 1. As a result, refiners must stop producing and delivering ethanol RBOB prior to May 1, leaving about six months to meet the 15 percent annual requirement, which then becomes an effective rate of about 30 percent.

⁴²Federal Highway Administration, U.S. Department of Transportation, *Monthly Motor Fuel Reported by States*, (Washington, DC: August 1993), Table MF-33GLA.

⁴³Although the Federal Highway Administration's gasohol sales do not reflect all ethanol that may have been used in the Northeast, the ROS requirements are still far in excess of historical capability, and infrastructure changes will be needed.

⁴⁴"Storage and Supply Sources are Sufficient for New ROS Demands," *Fuel Reformulation*, Vol. 4, No. 3, (Denver, CO: Hart Publications, May/June 1994), p. 63.

blending unit could take from 3 to 6 months. EPA indicated that building new storage can take from 6 to 18 months. The time lags required to convert or build new storage may be problematic for 1995 since the ROS credits will not be able to be earned during the 5.5 VOC-controlled months in the middle of the year. Storage and blending capability may not be in place to produce ethanol RFG at even 12.6 MBPD in the Northeast until the Fall of 1995.

- **The large ethanol demand increase in the Northeast indicates that larger ethanol volumes must flow to the Northeast from the Midwest than have occurred historically.** No studies were done for this report to determine if adequate rail road car, truck and barge tankage is available. EPA indicated in its final rule that its studies showed transportation supply should be adequate to move ethanol to the Northeast. Once it arrives, the question still remains whether or not adequate truck capability exists to deliver it to the terminal network. Truck capacity in the Northeast historically has been in short supply during cold weather. Severe cold weather can also disrupt the deliveries of ethanol to the Northeast. In the long term, ethanol stocking practices would help to cushion weather contingencies, but for early 1995, storage capability will possibly be inadequate for normal ROS operations, much less providing for contingency considerations.
- **The ROS adds product segregation and associated loss of flexibility in the delivery system on top of the segregation requirements of the RFG program.** Table 4.1 illustrates the increase in product segregation requirements facing the oil industry.

RBOB⁴⁵ would probably have been used by companies currently using ethanol as an oxygenate and by importers, who have fewer paperwork requirements with RBOB than with RFG. The ROS requires more terminals to use ethanol than would be the case without the mandate. Since in most cases, ethanol blends cannot meet the VOC control restrictions during the summer, terminals using ethanol will have to switch to an ether blend during the summer. Thus, terminals may be dealing with RBOB storage, ethanol storage and RFG storage (if ether RFG is being supplied rather than ether-RBOB).

To illustrate, consider the case in which a company was planning on using only MTBE-RFG prior to the ROS. This company would need ether-RFG storage, and it would turn its tanks from winter to summer (high-ozone season) by gradually adding low volatility ether RFG to the system prior to May 1, reaching the proper volatility level by May 1. To meet the ROS, the company may now have to use ethanol during the winter months. In this situation, both RBOB and ethanol storage will be needed. Ethanol-RBOB tanks will have to be turned prior to the high-ozone season to store ether-RFG. Since RBOB and RFG cannot be mixed, the ethanol-RBOB tank must be emptied before the ether-RFG can be added, stressing storage flexibility further.

⁴⁵Recall that RBOB is essentially RFG excluding the oxygenate. The regulation requires that each oxygenate-type RBOB must be kept segregated from all other products and other RBOBs.

Survey Results

- At the time the EIA survey was taken, many responding refiners did not yet have defined plans for meeting the ROS. Several common themes recurred in their responses that indicated the industry will not be able to "hit the ground running" to meet the ROS requirement in January 1995.

Of 38 refiners indicating plans to produce RFG (see Appendix B):

- 20 indicated they would not have sufficient ethanol supplies to comply with the ROS requirements and 8 said they were uncertain if they can obtain adequate ethanol, ETBE and/or credits from other companies.
- 18 indicated they would possibly need new storage facilities for either RBOB or ethanol.
- The pipelines and bulk terminals responding to the survey are moving to provide fuel ethanol blending, but it is not clear when it will be ready.
 - Of the 15 pipelines that plan on shipping RFG, 6 indicated that they are planning to offer fuel ethanol blending at their pipeline terminals. (Some pipelines do not offer fuel blending of any kind.)
 - Of 17 bulk terminals planning to handle RFG, 8 indicated plans to offer fuel ethanol blending.
- In phone conversations with marketers, several indicated that customers in the Northeast are reluctant to purchase a product containing ethanol. While customer acceptance will not stop the program, if it is a widespread problem, customer acceptance may become another factor keeping the ROS program from beginning at full implementation.
- The additional segregation requirements for ethanol-RFG create increased chances of local supply problems over and above the RFG program concerns. Increased use of RBOB's and ethanol in the Northeast decreases flexibility and increases the odds of local supply shortages over the situation resulting from the RFG program alone. Concerns have also been raised that the ethanol distribution system is subject to weather disruptions, and while the program is being put in place, lack of inventory cushion and adequate truck availability could create supply problems during a cold weather snap.

Ethanol Characteristics Affecting Deliverability

"As engine fuels, ethanol and methanol have similar chemical and physical characteristics. Methanol is methane with one hydrogen molecule replaced by a hydroxyl radical (OH), and similarly, ethanol is ethane with a hydrogen molecule replaced by a hydroxyl radical.

"The addition of the OH radical adds polar characteristics to these molecules. Polarity in a molecule is a highly cohesive binding force. Alcohols with small hydrocarbon structures like methanol and ethanol have strong polarity, while alcohols with larger hydrocarbon structures have weak polarity. MTBE and ETBE, which are made from methanol and ethanol, respectively, are ethers. Ethers do not have the OH radical, and have little or no significant polarity.

"At room temperature, low-molecular-weight substances like methanol would be gases if polarity did not keep them collapsed into liquids. When methanol or ethanol is dissolved in a nonpolar solvent like gasoline, the alcohol molecules become separated, and the molecular cohesion is weakened. The alcohol behaves more like a gas in such a mixture and results in a larger than anticipated increase in vapor pressure for the gasoline mixture than would be expected based on the alcohol's and gasoline's pure liquid vapor pressures. However, when alcohol concentrations in gasoline are at the 85-percent level, the Reid Vapor Pressure of the mixture is lower than that of gasoline alone. In addition, if water exists as a second phase with the gasoline, the polar alcohols will be drawn to the water, which is also highly polar. This becomes an issue in transporting and storing fuels because water frequently exists in tank bottoms and pipelines."

Energy Information Administration, *Alternatives to Traditional Transportation Fuels, An Overview*, DOE/EIA-0585/0 (Washington, DC, June 1994), p. 54.

5. RFG Supply and Demand Reconciliation

Major Findings

Results from EIA's refinery operations and import operations questionnaires and EIA estimates of supply from survey nonrespondents indicate that the planned supply of reformulated gasoline (RFG) is very closely balanced with expected demand. While a few refiners indicated they had additional RFG production capacity, the tight balance, combined with storage and distribution constraints imposed by the new gasoline regulations, suggests that the RFG market may be much more susceptible to supply disruptions than the traditional conventional gasoline system, especially during the early phases of the program.

The Northeast and Southern California have very high demands for RFG. Refiners in those regions are expected to produce RFG at or near their maximum capability. Production of RFG by refineries located in PADD I (primarily Delaware, Pennsylvania, and New Jersey) will be supplemented by RFG deliveries from the Gulf Coast and imports. Gulf Coast refineries report enough excess capacity to be able to make up for the loss of RFG production from any one refinery in PADDs I, II, or III, but this extra capacity may not be available immediately to replace a sudden loss. The West Coast has less flexibility. Since Southern California refineries are expected to be operating at or near maximum capacity for RFG production and this region has no nearby supply alternatives, a loss of one refinery presents the potential for a significant supply disruption.

- **PADD I is exposed to a potential extended shortfall should it experience a loss of supply of as little as 90 MBD.** Production is tight, and a sudden loss of RFG supply of 90 MBD would be difficult to remedy quickly. Since PADD I is dependent on distant supplies for 56 percent of its estimated RFG supplies, and excess capacity in PADD III may not be immediately available, only inventories would be available to remedy the immediate situation. Replacement supplies could take from two to four weeks if they must come from imports or the Gulf Coast.
- **Demand increases in PADD I, on the other hand, will probably not create shortages, but can still tighten the market enough to increase prices.** Historical demand variations suggest that the Northeast could experience an RFG demand increase of up to 50 MBD above EIA estimates. While such an increase would likely impact inventories and affect prices, it would probably not create shortages.
- **PADD V, especially California, is exposed to potential extended shortfall should any of its refineries experience a problem.** Since PADD V refineries are expected to produce RFG at near capacity levels, the shutdown of a single refinery is likely to result in immediate inventory drawdowns and upward pressure on prices. Supply replacement

could take up to two to four weeks, if those supplies must come from outside the affected areas (imports or the Gulf Coast).

- **EIA's Market Clearing Estimate (supply/demand balance) requires larger than average flows of gasoline among PADDs I, II, and III.** This suggests that the distribution system has lost some of its flexibility to respond to contingencies. EIA's Market Clearing Estimate requires historical winter maximum pipeline flows of gasoline to move from PADD III into PADDs I and II, and from PADD II into PADD I. Additionally, larger than average marine flow from PADD III up the coast to the Northeast will be required. Since these flow levels are also a function of demand, lower than forecasted demand offers an opportunity for relief in the deliverability system. However, if gasoline demands are higher, the system is likely to be stressed even further.
- **Higher costs of production and distribution will be passed through, at least partially to RFG prices.** EIA estimates the cost of producing RFG to be 4 to 6 cents per gallon higher than conventional unleaded gasoline. The low end of the range corresponds to reformulated gasoline with 2.0 weight percent oxygen and oxygenate market prices corresponding to those observed during the past two winter oxygenate seasons.⁴⁶ The high end to the range corresponds to oxygenated reformulated gasoline with 2.7 weight percent oxygen and oxygenate market prices for the third quarter 1994.
- **Should a loss of supply occur in PADD I or V, price will respond.** Historically, low sulfur diesel provides an analogy. When local shortages of this product occurred during the start-up of the program, prices increased temporarily as much as 30 cents per gallon in some areas, and rose and fell over the course of a month. Markets generally respond quickly to such events by increased refinery production or other appropriate remedies.

Method for Analyzing the Supply/Demand Balance

EIA figures for January 1995, supply and demand data were either obtained from the survey or estimated. The data were available on a sub-PADD basis and covered production, stock changes, imports, and consumption. EIA reconciled these data using historical trends to investigate the ability of the industry's plans to meet EIA forecasted demand this coming January.

A summary of RFG balance, developed using the Market Clearing Estimate, is shown in Table 5.1. The Market Clearing Estimate has 2,439 MBD of RFG production and 174 MBD of RFG imports meeting 2,519 MBD of demand and 96 MBD of stock builds. Table 5.2 shows the PADD balances and movements between PADDs for RFG (including OPRG), oxygenated gasoline, and conventional gasoline.

⁴⁶Energy Information Administration, "Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995," *Petroleum Marketing Monthly*, August 1994, DOE/EIA-0380(94/08) (Washington, DC, August 1994) pp xiii-xxii.

Table 5.1. RFG Market Clearing Estimate Summary (Including OPRG), January 1995
(Thousand Barrels per Day)

	Planned Production	Market Clearing Case					
		Produced	Net Recd.	Imports	Stock Build (Draw)	Total Supply	Demand
PADD IA	0	0	296	55	13	338	338
PADD IB	605	605	278	117	36	965	965
PADD IC	19	19	111	2	4	128	128
PADD I	624	624	685	174	54	1,431	1,431
PADD II	297	297	56	0	12	341	341
PADD III	1,005	1,005	(749)	0	10	247	247
PADD IV	0	0	0	0	0	0	0
PADD V	513	513	7	0	20	500	500
Total US	2,439	2,439	0	174	96	2,519	2,519

Notes: Totals may not equal sum of components due to independent rounding.
Negative quantities are shown in parenthesis (). Net Received (Net Recd.) equals the difference between gross receipts and gross shipments.

Source: EIA estimates.

Table 5.2. Market Clearing Estimate by Type of Gasoline, January 1995
(Thousand Barrels per Day)

	Produced	Receipts	Shipments	Net Recd	Imports	Net Stock Build	Total Supply	Demand
PADD IA								
RFG	0	296	0	296	55	13	338	338
Oxy-Gaso	0	0	0	0	0	0	0	0
Cnv-Gaso	0	19	0	19	0	1	18	18
Totals:	0	315	0	315	55	14	356	356
PADD IB								
RFG	605	529	251	278	117	36	965	965
Oxy-Gaso	0	0	0	0	0	0	0	0
Cnv-Gaso	158	0	54	(54)	0	4	101	101
Totals:	763	529	305	225	117	40	1,066	1,066
PADD IC								
RFG	19	610	498	111	2	4	128	128
Oxy-Gaso	8	60	14	46	0	(5)	59	59
Cnv-Gaso	0	1,126	83	1,042	40	34	1,048	1,048
Totals:	27	1,795	595	1,199	42	33	1,235	1,235

See notes at the end of the table.

Table 5.2. Market Clearing Estimate by Type of Gasoline, January 1995 (Continued)
(Thousand Barrels per Day)

	Produced	Receipts	Shipments	Net Recd	Imports	Net Stock Build	Total Supply	Demand
PADD I								
RFG	624	729	43	685	174	54	1,431	1,431
Oxy-Gaso	8	60	14	46	0	(5)	59	59
Cnv-Gaso	158	1,091	83	1,008	40	39	1,167	1,167
Total	790	1,879	140	1,739	214	87	2,656	2,656
Jan 94	750	1,509	166	1,343	199	(26)	2,318	2,318
PADD II								
RFG	297	130	74	56	0	12	341	341
Oxy-Gaso	136	14	76	(62)	0	(3)	77	77
Cnv-Gaso	1,367	423	0	423	0	63	1,727	1,727
Totals:	1,800	567	150	417	0	72	2,145	2,145
Jan 94	1,742	578	122	456	(1)	126	2,071	2,071
PADD III								
RFG	1,005	0	749	(749)	0	10	247	247
Oxy-Gaso	87	29	95	(66)	0	(15)	36	36
Cnv-Gaso	2,170	0	1,413	(1,413)	0	30	727	727
Totals:	3,262	29	2,256	(2,227)	0	25	1,010	1,010
Jan 94	3,087	36	1,914	(1,878)	(77)	51	1,082	1,082
PADD IV								
RFG	0	0	0	0	0	0	0	0
Oxy-Gaso	40	47	2	45	0	(4)	89	89
Cnv-Gaso	187	0	45	(45)	0	10	132	132
Totals:	227	47	47	0	0	6	221	221
Jan 94	240	44	48	(3)	0	20	217	217
PADD V								
RFG	513	7	0	7	0	20	500	500
Oxy-Gaso	550	37	0	37	0	0	587	587
Cnv-Gaso	183	27	0	27	0	40	170	170
Totals:	1,245	71	0	71	0	60	1,256	1,256
Jan 94	1,277	86	4	82	(12)	120	1,227	1,227

Notes: Totals may not equal sum of components due to independent rounding. • Negative quantities are shown in parenthesis (). • Net Received (Net Recd.) equals the difference between gross receipts and gross shipments. • Oxygenated Program Reformulated Gasoline is included in the RFG category. • January 1994 imports are the difference between gross imports and gross exports.

Source: *Petroleum Supply Annual*, 1994. EIA estimates.

The methodology used to balance supply and demand was a simple allocation of production and imports to meet EIA estimated demand and stock builds in each sub-PADD, subject to constraints on the ability of products to move between PADDs. Directional economics were assumed to set priorities on how supply moved.

As described in the chapter on supply, the production available to meet demand was a combination of survey results and EIA estimations for nonrespondents. RBOB was treated as RFG (with a volume adjustment for oxygenate addition), and individual oxygenates were assumed to be available for the RFG planned to be produced (no separate consideration was given to ethanol availability). Imports likely to be available in January 1995 to meet demand were estimated from historical imports and survey responses. Stock builds or draws were estimated for January from historical data on oxygenated and conventional gasolines. The ability of production to move from one PADD to another was based on historical pipeline and marine flows.

The balance was done at the PADD level only to demonstrate whether the physical system might be able to produce and move product to the appropriate consuming areas. Once inside a PADD, the methodology assumes that necessary exchanges and other financial transactions take place to move the product to the appropriate area. Chapter 4, RFG Deliverability, addresses the potentially larger problem of intra-PADD movements where the system must try to move the products from major pipelines and seaports to the specific areas where needed.

In the Market Clearing Estimate, total gasoline pipeline flows were not allowed to exceed the highest gasoline flow that occurred during the months of December, January or February from 1992 through 1994. EIA does not publish pipeline flow data on a sub-PADD basis, so the flow from PADD IA to IB was capped at a figure used by Bonner & Moore in an earlier RFG study.⁴⁷ For the Market Clearing Estimate, at or near the maximum flows are required for product moving from PADD III to PADD I, from PADD III to PADD II, and from PADD II to PADD I.

Various factors can impact pipeline capacity. Gasoline does not flow alone in the pipeline, but is accompanied by distillates and other products. By choosing the largest historical winter gasoline flow as a maximum, distillate flow is considered. However, during a cold snap, one would expect distillate flow to increase substantially at the expense of gasoline. The EIA historical gasoline minimum and maximum pipeline flows during the winter months from 1992 through 1994, and the flows in the Market Clearing Estimate, are summarized in Table 5.3.

Tankers and barges are a more expensive means of moving product long distances than pipelines; however, the amount of product moved by water can vary considerably, limited only by the number of ships and harbor facilities, and marine flows can move in any direction. In the Market Clearing Estimate, marine flows were allowed to deviate somewhat from historical figures as summarized in the Table 5.4.

⁴⁷Bonner & Moore, *Reformulated Gasoline: Cost, Distribution and Compliance Implications*, June 1994, Table 3.3.

A more detailed display of the Market Clearing Estimate flows is shown in Tables 5.5 and 5.6. Contrary to historical flows, EIA shows some conventional gasoline being moved from PADD IB south to IC. This is due to PADD IB needing little conventional gasoline relative to RFG, and to PADD IB refiners having to co-produce conventional gasoline as they produce to meet RFG demand.

Table 5.3. Historical Pipeline Flows of Motor Gasoline (Including Blending Components)

From PADD	To PADD	Historical		EIA Case
		Maximum MBD	Minimum MBD	
I	II	188	146	140
II	I	41	26	41
II	III	40	24	29
II	IV	65	42	47
III	I	1,404	1,113	1,404
III	II	392	193	369
III	V	52	36	42
IV	II	18	14	18
IV	V	35	25	29

Notes: Minimums and maximums represent the monthly extremes of pipeline flows during the months of December, January, and February for the years 1992 through 1994.

Source: EIA estimates. *Petroleum Supply Annual*, 1992, 1993 and 1994.

Table 5.4. Tanker and Barge Flows of Motor Gasoline (Including Blending Components)

From PADD	To PADD	Historical		EIA Case
		Maximum MBD	Minimum MBD	
I	II	2	0	0
I	III	9	0	0
II	I	33	21	33
II	III	7	0	0
III	I	356	254	401
III	II	60	37	40
III	V	9	0	0
V	I	10	0	0

Notes: Minimums and maximums represent the monthly extremes of tanker and barge flows during the months of December, January, and February for the years 1992 through 1994.

Source: EIA estimates. *Petroleum Supply Annual*, 1992, 1993, and 1994.

**Table 5.5. Market Clearing Estimate, Total Finished Motor Gasoline Shipped, By Mode,
January 1995
(Thousand Barrels per Day)**

FROM:	TO: ---->								Totals
	PADD IA	PADD IB	PADD IC	PADD I	PADD II	PADD III	PADD IV	PADD V	
PADD IA									
Pipeline	--	0	0	--	0	0	0	0	N/A
Marine	--	0	0	--	0	0	0	0	N/A
Totals	--	0	0	--	0	0	0	0	N/A
PADD IB									
Pipeline	0	--	0	--	0	0	0	0	N/A
Marine	270	--	35	--	0	0	0	0	N/A
Totals	270	--	35	--	0	0	0	0	N/A
PADD IC									
Pipeline	0	455	--	--	140	0	0	0	N/A
Marine	0	0	--	--	0	0	0	0	N/A
Totals	0	455	--	--	140	0	0	0	N/A
PADD I									
Pipeline	--	--	--	--	140	0	0	0	140
Marine	--	--	--	--	0	0	0	0	0
Totals	--	--	--	--	140	0	0	0	140
PADD II									
Pipeline	0	41	0	41	--	29	47	0	117
Marine	0	33	0	33	--	0	0	0	33
Totals	0	74	0	74	--	29	47	0	150
PADD III									
Pipeline	0	0	1,404	1,404	369	--	0	42	1,815
Marine	45	0	356	401	40	--	0	0	441
Totals	45	0	1,760	1,805	409	--	0	42	2,256
PADD IV									
Pipeline	0	0	0	0	18	0	--	29	47
Marine	0	0	0	0	0	0	--	0	0
Totals	0	0	0	0	18	0	--	29	47

See notes at the end of the table.

Table 5.5. Market Clearing Estimate, Total Finished Motor Gasoline Shipped, By Mode, January 1995
(Thousand Barrels per Day)

FROM:	TO: ---->								Totals
	PADD IA	PADD IB	PADD IC	PADD I	PADD II	PADD III	PADD IV	PADD V	
PADD V									
Pipeline	0	0	0	0	0	0	0	--	0
Marine	0	0	0	0	0	0	0	--	0
Totals	0	0	0	0	0	0	0	--	0

Notes: N/A=Not applicable, as these include intra-PADD I movements. Totals may not equal sum of components due to independent rounding.

Source: EIA estimates.

Table 5.6. Market Clearing Estimate, Product Shipment Detail by Type of Gasoline, January 1995 (Continued)
(Thousand Barrels per Day)

FROM:	TO: ---->								Totals
	PADD IA	PADD IB	PADD IC	PADD I	PADD II	PADD III	PADD IV	PADD V	
PADD IA									
RFG	--	0	0	--	0	0	0	0	N/A
Oxy-Gaso	--	0	0	--	0	0	0	0	N/A
Cnv-Gaso	--	0	0	--	0	0	0	0	N/A
Totals	--	0	0	--	0	0	0	0	N/A
PADD IB									
RFG	251	--	0	--	0	0	0	0	N/A
Oxy-Gaso	0	--	0	--	0	0	0	0	N/A
Cnv-Gaso	19	--	35	--	0	0	0	0	N/A
Totals	270	--	35	--	0	0	0	0	N/A
PADD IC									
RFG	0	455	--	--	43	0	0	0	N/A
Oxy-Gaso	0	0	--	--	14	0	0	0	N/A
Cnv-Gaso	0	0	--	--	83	0	0	0	N/A
Totals	0	455	--	--	140	0	0	0	N/A
PADD I									
RFG	--	--	--	--	43	0	0	0	43
Oxy-Gaso	--	--	--	--	14	0	0	0	14
Cnv-Gaso	--	--	--	--	83	0	0	0	83
Totals	--	--	--	--	140	0	0	0	140
Jan 94	--	--	--	--	158	0	0	0	166

See notes at the end of the table.

Table 5.6. Market Clearing Estimate, Product Shipment Detail by Type of Gasoline, January 1995 (Continued)
(Thousand Barrels per Day)

FROM:	TO: ---->								Totals
	PADD IA	PADD IB	PADD IC	PADD I	PADD II	PADD III	PADD IV	PADD V	
PADD II									
RFG	0	74	0	74	—	0	0	0	74
Oxy-Gaso	0	0	0	0	—	29	47	0	76
Cnv-Gaso	0	0	0	0	—	0	0	0	0
Totals	0	74	0	74	—	29	47	0	150
Jan 94	NA	NA	NA	49	—	29	44	0	122
PADD III									
RFG	45	0	610	655	87	—	0	7	749
Oxy-Gaso	0	0	60	60	0	—	0	35	95
Cnv-Gaso	0	0	1,091	1,091	322	—	0	0	1,413
Totals	45	0	1,760	1,805	409	—	0	42	2,256
Jan 94	NA	NA	NA	1,456	403	—	0	55	1,914
PADD IV									
RFG	0	0	0	0	0	0	—	0	0
Oxy-Gaso	0	0	0	0	0	0	—	2	2
Cnv-Gaso	0	0	0	0	18	0	—	27	45
Totals	0	0	0	0	18	0	—	29	47
Jan 94	NA	NA	NA	0	16	0	—	31	48
PADD V									
RFG	0	0	0	0	0	0	0	—	0
Oxy-Gaso	0	0	0	0	0	0	0	—	0
Cnv-Gaso	0	0	0	0	0	0	0	—	0
Totals	0	0	0	0	0	0	0	—	0
Jan 94	NA	NA	NA	4	0	0	0	—	4

Notes: NA=Not Available. N/A=Not applicable, as these include intra-PADD I movements. Totals may not equal the sum of components due to independent rounding. Oxygenated Program Reformulated Gasoline is included in the RFG category.

Source: EIA estimates.

Critical Assumptions Underlying the EIA Estimate

As in any estimation process, certain conditions cannot be precisely defined and reasonable values must be used. This section outlines major assumptions underlying the estimates of demand and supply as well as the market behavior that will reconcile the two.

Demand

A critical assumption affecting EIA's RFG estimate is the spillover rate. For every 1 percent deviation from the 5 percent assumed in the EIA estimate, demand can rise or fall about 25 MBD. Thus, if a reasonable range was from 3 to 7 percent, total U.S. demand could vary demand anywhere within a 100 MBD band. Less critical are vehicle miles traveled and fuel efficiency, which could vary demand plus or minus 10 and 8 MBD, respectively.

Another critical assumption is that overall gasoline demand will follow the historical trend. Actual gasoline demand fluctuates around this trend. For example, during the past 10 years, January gasoline demand in PADD I has exceeded the historical trend by about 100 MBD twice. Such a deviation this coming January would result in about a 50 MBD increase in RFG demand; however current gasoline demand levels imply such an increase is unlikely.

New Supply

While production estimates for the clearing case were derived from the survey results and EIA estimates of production for nonrespondents, industry plans will change and adapt to further market information as January approaches. In addition, the nonresponse estimates were based on refinery equipment, market areas served by individual refineries, actual production of oxygenated gasoline, and other information including press announcements. However, the survey is the compilation of individual company responses and not an industry-wide coordinated plan.

Since this report does not address price *per se*, the short-term supply curve is assumed to be virtually flat. In fact, crude runs and yields change in response to higher refinery margins.

Overall import levels were based on historical import flows of gasoline adjusted to exclude marginal, one-time shipments. These so-called contract imports are an important supply source for the Northeast. Even though spot shipments of gasoline are infrequent during January, some foreign refiners are capable of importing RBOB or even RFG, if the price is right. EIA's market clearing estimate of 174 MBD is based on survey results and press announcements.

Deliverability

Changes in supply or demand patterns, as well as logistical issues, can affect deliverability. Historically, variations in gasoline demand over an estimated trend from 1983 to 1994 were as high as 168 MBD over the estimate to 230 MBD under the estimate. Overall U.S. demand variations do not reflect the regional fluctuations that comprise the overall variation. Usually regions do not change uniformly. For example, PADD I showed an increase of 140 MBD over the 10-year trend in one year, a different year from that in which the total U.S. demand varied by 168 MBD. To the extent that such regional variations occur, the problems confronting distribution and storage increase, particularly in PADDs I and V. Meanwhile, in the market clearing case, barge deliveries provide the surge capacity, but this could be adversely impacted by bad weather. Moreover, there is no good benchmark for determining capacity constraints on various arteries.

A new source of uncertainty brought out by a number of the pipelines in the survey and in conversations is that the additional segregation requirements will slow flow in some of the pipelines. Estimates ranged from a decline in flow of 1 to 10 percent (see the RFG Deliverability chapter). In the Market Clearing Estimate, the maximum pipeline volumes assumed are probably less than pipeline capacity. Also, under normal operations, marine traffic could accommodate some additional flows. The issue is not so much adjusting to a slowly changing normal operating level, but the limited ability of the system to adjust to quick changes. Surge capacity and ability to divert and substitute products will be reduced under the RFG program.

The EIA estimate makes the implicit assumption that an efficient exchange process will be in place and will not encumber the distribution of RFG. If that assumption is not valid, the distribution *and* certification process could be less efficient during the first month of the program. Finally, the EIA estimate makes no allowance for implementation of the Renewable Oxygenates Standard (ROS), and the deliverability of ethanol, particularly in the Northeast. All that can be said at this point is that deliverability would be hampered.

Analysis of Plausible Contingencies

As previously stated, the Market Clearing Estimate is relatively tight. All of the planned production was needed to meet demand and normal stock builds in a relatively low-demand month (January). As a result, EIA investigated uncertainties surrounding events that may affect demand, production, and imports. As shown by the problems experienced during the introduction of low-sulfur diesel fuel, RFG planning should include attention to possible unforeseen circumstances that could negatively impact the availability of RFG to end-users. While it is not EIA's intent to list all possible contingencies and potential remedies here, assessment of the adequacy of RFG supply and deliverability requires some discussion of such events. For purposes of this report, only problems potentially affecting entire regions are considered, under the assumption that smaller localized outages will generally result in shifting of product flows within the region to compensate.

The two areas of vulnerability that EIA was able to quantitatively explore were loss of supply and unexpectedly high demand for RFG. Other areas of uncertainty are also important, but could not be quantified. For example the loss of flexibility in the delivery system, which may result in localized shortages, cannot be quantified with the data available. Another important area of uncertainty is the system adjustment required for any new petroleum product introduction. The RFG program requires much greater change in the system from production through to the retailer than any other new product introduction to date; however insights can be gained from recent experiences with oxygenated gasoline and low sulfur diesel, which will be discussed at the end of this chapter.

While an unlimited number of events and scenarios can be constructed, past experience suggest the following as both plausible and significant.

Higher Than Expected Demand

The projected January 1995 total U.S. gasoline demand of 7,288 MBD in the Market Clearing Case is from the EIA's *Short-term Energy Outlook, Third Quarter 1994*, base case.⁴⁸ With the *Short-Term Energy Outlook's* low world oil price⁴⁹ and the high macro (gross domestic product) cases, U.S. gasoline demand may be 1.1 percent higher than the base case demand. If this demand increase were experienced evenly throughout the country, total RFG demand would increase less than 28 MBD, 16 MBD in PADD I alone. Estimation of uncertainty in the forecast may be greater, giving a sound foundation for an hypothesized 100 MBD rise in PADD I.

- **Surge in demand.** Table 5.7 illustrates a case in which total gasoline demand was increased by 100 MBD in PADD I. (Variations of this size over the trend average have occurred twice during the last 10 years in PADD I.) This results in an RFG demand increase of about 53 MBD. Historically, production does not pick up immediately when demand exceeds expected levels. In the RFG environment, production, if available, will be even slower to respond. The result in this situation is that PADD I will not be able to build stocks to the same degree, and areas like sub-PADDs IA and IB may even see a little stock draw. While PADD I would be expected to survive January, the lack of stock builds could give rise to future supply concerns and put upward pressure on prices. A demand increase has the advantage of affecting all gasoline products and all refiners serving the region, versus a production loss that can result in the loss of a single specialized product.
- **Extreme cold weather impacts.** One concern EIA explored was the impact of a cold January on the ability to supply RFG. Cold weather has mixed impacts on the ability to supply gasoline. Pipeline capacity for gasoline can be reduced due to increased demand for distillates (and, in some cases, propane) that share the same pipeline. If severe cold weather is also accompanied by frozen waterways and bad road conditions, trucks can experience delays in delivery and waterborne shipments are stopped or slowed. However, some road conditions can keep drivers at home, thereby reducing the demand for gasoline. EIA looked at the worst case for PADD I in which demand stayed at the base case level but pipeline capacity for gasoline was reduced due to high distillate throughput. Since January 1992, the highest distillate throughput occurred in February 1994. (Coincidentally, gasoline throughputs were down due to bad road conditions.) At this high distillate and kerosene level, 1,375 MBD is still available for all gasolines in pipelines moving from PADD III to I, which is 80 MBD lower than the EIA Market Clearing Estimate. The 80 MBD reduction would not all be RFG (and might not be any RFG). It is likely that most of the pipeline reduction would be at the expense of conventional gasoline, since it is easier to replace than RFG. The impact of cold would probably not reduce PADD I RFG to a stock draw situation; although stock builds would not be as healthy as in the EIA Market Clearing Estimate.

⁴⁸Energy Information Administration, *Short-Term Energy Outlook, Third Quarter 1994*, DOE/EIA-0202(94/3Q)(Washington, DC, August 1994).

⁴⁹This high case assumes that the imported crude oil price is \$3.00 below and the annual change in gross domestic product is 1.4 higher than the base case as reflected in the Market Clearing Case.

Table 5.7. RFG High Demand Summary (Including OPRG), January 1995
(Thousand Barrels per Day)

	Planned Production	High Demand: +100 MBD PADD I						
		Produced	Net Recd.	Imports	Stock Build (Draw)	Target Stock Build	Total Supply	Demand
PADD IA	0	0	296	55	0	13	351	351
PADD IB	605	605	276	117	(3)	36	1,001	1,001
PADD IC	19	19	115	2	2	4	133	133
PADD I	624	624	686	174	(0)	54	1,484	1,484
PADD II	297	297	56	0	12	12	341	341
PADD III	1,005	1,005	(749)	0	10	10	247	247
PADD IV	0	0	0	0	0	0	0	0
PADD V	513	513	7	0	20	20	500	500
Total US	2,439	2,439	(0)	174	42	96	2,571	2,571

Notes: Totals may not equal the sum of components due to independent rounding. • Negative quantities are shown in parenthesis (). • Net Received (Net Recd.) equals the difference between gross receipts and gross shipments.

Source: EIA estimates.

Sudden Loss of Refinery Production Capability

The most important uncertainty surrounding production is the potential loss of refinery capacity in PADDs I or V. These areas do not have extra RFG production capability, and the industry's ability to replace a large volume of RFG quickly is limited. To illustrate this situation, consider the loss of a large refinery in PADD I producing 90 MBD of RFG, which might result in a case similar to that shown in Table 5.8. In this case, PADD I must draw down stocks when it normally would be building, and PADD II is unable to build stocks due to PADD II supply being diverted to PADD I.

Prior to RFG, many other sources would potentially be able to supply the lost product from the incapacitated refinery. Between rapid exchanges and arrangements to get extra product moving by pipeline from the Gulf, the problem would soon be remedied. Under the RFG program, the situation will become more complicated:

- Fewer refiners will be capable of meeting the unique specifications of the product that was lost (e.g., if the refinery was producing ethanol RBOB, other refiners would not necessarily be able to supply ethanol RBOB).
- In EIA's Market Clearing Estimate, although there is limited capacity for pipeline movements from PADD III to the RFG consuming areas in PADD I, there is no extra production capacity assumed to be available. Also, no extra supplies of RFG were available in PADDs I or II in the EIA estimate.

Table 5.8. RFG Production Loss Summary (Including OPRG), January 1995
(Thousand Barrels per Day)

	Planned Production	Production Loss: (90 MBD) PADD I						
		Produced	Net Recd.	Imports	Stk Build (Draw)	Target Stk Build	Total Supply	Demand
PADD IA	0	0	283	55	(0)	13	338	338
PADD IB	605	515	319	117	(13)	36	965	965
PADD IC	19	19	107	2	0	4	128	128
PADD I	624	534	709	174	(13)	54	1,431	1,431
PADD II	297	297	44	0	0	12	341	341
PADD III	1,005	1,005	(759)	0	0	10	247	247
PADD IV	0	0	0	0	0	0	0	0
PADD V	513	513	6	0	19	20	500	500
Total US	2,439	2,349	0	174	6	96	2,518	2,518

Notes: Totals may not equal the sum of components due to independent rounding. • Negative quantities are shown in parenthesis (. • Net Received (Net Recd.) equals the difference between gross receipts and gross shipments.

Source: EIA estimates.

The likelihood of the 90 MBD loss case is increased by the fact that a number of refiners in PADD I are producing RFG at approximately that rate. (The case assumed some conventional gasoline was lost as well, but the conventional loss had no adverse impact.) PADD I will be reduced to a stock draw situation soon after the production loss, and relief will not be quick in coming. Again, the tight balance in the Northeast would require replacement supplies either from the Gulf Coast, if available, or imports. It takes about 20 days to move product from the Gulf Coast to the Northeast. Transit times from supplemental sources such as Europe and Saudi Arabia are as high as 30 days. In addition, foreign refiners may have trouble duplicating the exact quality of the RFG lost. In this case, limited excess pipeline capacity would presumably be available, but the incremental amount of RFG that could be shipped would be dependent on demand for other products, particularly heating fuels.

PADD V is perhaps even more exposed than PADD I due to its isolation. The RFG areas in PADD V are concentrated in southern California, and only 7 refiners will be serving the area. Like PADD I, a number of these refiners are producing large volumes of RFG. For example, looking at the Market Clearing Estimate in Table 5.1, PADD V shows a demand of 500 MBD. If total production of 513 MBD were reduced to 423 MBD (90 MBD loss), production plus net receipts would only provide 430 MBD. Thus, a 70 MBD stock draw would take place to meet demand. PADD V would not be able to withstand that situation long without shortages occurring.

Reduced Availability of Imports

RFG imports are available on either a long-term contractual basis or a short-term spot basis that is usually price driven. A loss of imports, particularly those under long-term contract, is similar to a loss of production. Usually such losses would be from a single source, and thus the impact would be similar to losing production from a single refinery. No single source of imports is currently projected to be providing as much as 90 MBD of RFG, so the probability of a loss of this magnitude is small. However, a harbor problem that disrupts import off-loading could have the same effect. In the Northeast, the primary alternative source of supply would be increased shipments from the Gulf Coast, utilizing marine shipments and any available excess pipeline capacity. In California, marine shipments from the Gulf Coast would be the only significant alternative, and would involve time and cost penalties.

It is obvious from the above discussion that many plausible scenarios would involve a regional decrease in available supply that could not be fully offset by replacement product under current assumptions. As such, it may be prudent for Federal and State regulatory authorities to begin consideration of potential selective relief under specific conditions, in order to alleviate supply shortfalls and associated price impacts.

Precedents for New Product Introductions

In the widespread debate prior to the introduction of RFG, many comparisons have been drawn to other recent, seemingly similar mandated introductions of new petroleum product specifications: oxygenated gasoline in November 1992, and low-sulfur diesel fuel in October 1993. Each of these is instructive for the lessons that it can, and cannot, provide relevant to RFG. At least as many differences as similarities exist between these two introductions and the coming one, but the experiences in these two recent cases do furnish some basis for assessment of the likelihood and degree of possible negative consequences of temporary supply/demand imbalances.

Oxygenated Gasoline

In order to reduce carbon monoxide (CO) pollution in 39 nonattainment areas, the Clean Air Act Amendments of 1990 (CAAA90) mandated a minimum oxygen content in gasoline sold in those areas during the portion of the year (primarily winter months) when CO pollution exceeded maximum allowable standards. This program, about a third of the size of the RFG program, began nationally in November 1992, although several western states had pilot programs in place for several years. Prior to the beginning of the national program, many experts inside and outside the industry predicted gasoline and oxygenate supply and deliverability problems, along with the attendant potential for temporary shortages and price run ups. To the surprise of many, sufficient pre-season inventory was built with little fanfare (although unprecedented oxygenate demand brought sharply higher prices for MTBE), and no significant local or regional shortfalls developed. Spillover, expected to run as high as 22 percent, was in fact estimated at only 2 percent. As a result of adequate supply and lower-than-anticipated demand, price impacts were

Low-sulfur Diesel Fuel

In contrast to the introduction of oxygenated gasoline the year before, the advent of nationally-required low-sulfur diesel fuel created a degree of havoc in two significant regions of the country. Beginning in October 1993, CAAA90 required reduction of the sulfur content of on-highway diesel fuel to a maximum of 0.05 percent. Despite seemingly sufficient lead time, and any relevant lessons learned from the oxygenated gasoline experience, supply shortages quickly developed in the mid-continent and portions of California, leading to price run ups of as much as 30 cents per gallon. Temporary outages spread at both the retail and wholesale levels, and public outcry, particularly from the trucking industry, led to investigative hearings and limited relaxation of enforcement. The supply system responded quickly once the crisis developed, and the entire incident ran its course within the month of October.

The supply shortfall during the introduction of low-sulfur diesel fuel apparently resulted from an unanticipated combination of exacerbating factors:

- **Pipeline problems** - In early October, the Explorer Pipeline suffered erosion from floodwaters on the Missouri River between Tulsa and St. Louis, causing a precautionary shutdown. Because the Explorer is a critical supply link from the Gulf Coast to the mid-continent region, the temporary halt in its flow delayed shipments throughout much of PADD II, reducing available stock levels during the first several weeks of the low-sulfur diesel mandate.
- **Refinery problems** - Several refineries in California experienced equipment problems in September, again during the period when supply building was crucial. Particularly affected were downstream units critical to production of low-sulfur diesel fuel.
- **Superseding State requirements** - Concurrent with the low-sulfur on-highway diesel fuel introduction throughout the nation, the California Air Resources Board (CARB) mandated the use of a more restrictive diesel fuel specification, and its use by additional consuming segments (primarily agricultural). The tighter product specification increased costs and reduced the industry's diesel fuel production capacity, while the wider mandate resulted in higher demand.
- **Timing difficulties** - Also in California, the October 1 start date for low-sulfur diesel requirements struck during the peak of the autumn harvest season, increasing the impact on both the agricultural and transportation sectors.

6. Unresolved Issues

As a result of the complex changes required in the implementation of reformulated gasoline (RFG) and the extremely tight deadlines for compliance, it is understandable that several outstanding issues remain. This chapter describes several of the more critical issues and includes:

- Renewable Oxygenates Standard (ROS)
- Domestic Refiner Baseline Approvals
- In-line Blending Waivers
- Foreign Refiners' Baselines
- Health Effects of Fuel Oxygenates.

Renewable Oxygenates Standard (ROS)

The ultimate resolution of the Renewable Oxygenates Standard (ROS) is arguably the greatest uncertainty remaining for the start-up of the reformulated gasoline (RFG) program. Business decisions are being impacted awaiting final resolution of the lawsuit that the American Petroleum Institute and the National Petroleum Refiner's Association filed on July 13, 1994, against the EPA in the United States Court of Appeals for the District of Columbia Circuit.

On September 13, 1994, the Appeals Court granted a stay of the renewable oxygenate requirement for reformulated gasoline. The court will begin hearing oral arguments from all parties on the first available date following the January 12, 1995, filing of Final Briefs. Consequently, the requirement for the use of renewable oxygenates will not be in effect at the January 1, 1995, start-up of the RFG program. The long-term effect is still unresolved.

Domestic Refiner Baseline Approvals

A cornerstone of the Clean Air Act Amendment specifications for RFG is the 1990 baseline. The baseline is used as a performance measure for both RFG and conventional gasoline. Literally *all* gasoline sold in the United States is subject to comparison to a 1990 baseline.

Baselines were required to be submitted by refiners, blenders, and importers by June 1, 1994. Extensions to September 1, 1994, were granted for exceptional cases. There has been an overwhelming amount of information included in baseline submissions, complicating the approval process. It is not certain when EPA will complete its determinations on baseline approval. Until

an individual baseline is officially approved, gasoline manufacturers produce gasoline "at risk" and are subject to retroactive fines and penalties if the gasoline manufactured is in compliance.

According to EPA, as of August 29, 1994, EPA had received 269 baseline submissions and expected about 20 more. Of the 269 received, 154 were individual baselines and 115 were statutory baselines. All 154 individual baselines have received a Level 1 (cursory) review and 77 had received or are in Level 2 (spot checks of calculations and reasonableness checks). Baseline approval is expected to begin before the end of September.

In-line Blending Waivers

Several refiners have requested in-line blending waivers in order to produce RFG. As of September 16, EPA indicated that they had reached agreement with each company requesting a waiver and that the process was working smoothly. EPA began the approval of in-line blending waiver requests during the week of September 12, 1994.

Foreign Refiners' Baselines

The EPA proposed new rules for determining the baseline values of foreign refiners for the purpose of certifying RFG.⁵⁰ The proposed rules allow foreign refiners to establish their own individual 1990 baseline rather than being forced to utilize the statutory baseline of the Clean Air Act as amended in 1990.

The issue of certification of imports is most important for the Northeastern States that have historically relied on imports for approximately 10 percent of their gasoline supply. U.S. refiners have opposed any concession to foreign refiners, arguing that air quality would suffer. PDVSA has argued that the December final rules on RFG discriminated against foreign refiners and that the gasoline they export to the United States is generally cleaner than comparable grades of gasoline manufactured in the United States.

On September 12, 1994, the U.S. House of Representatives voted to deny the EPA funds required to enforce its proposed rule to allow foreign refiners to certify RFG using their own 1990 baseline.^{51 52} The Senate had already passed a similar provision. Under these circumstances the EPA must determine what future course of action will be pursued. Foreign refiners were required to use the statutory baseline in the original final rules on RFG released in December 1993.

⁵⁰ *Federal Register*, May 3, 1994, p.22800-22814.

⁵¹ "Gas Lines, Higher Cost Seen in Tighter Rule on Refined Imported Gas," *Washington Times*, September 14, 1994, p.B12.

⁵² "House Votes to Deny EPA Funds to Enforce Foreign Refiners Rule; Hearing Set on Issue," *The Oil Daily*, September 14, 1994, p.1.

Health Effects of Fuel Oxygenates

The initial use of MTBE as an oxygenate in Alaska during the 1992-1993 oxygenated fuel season caused a wave of complaints and concern over the use of MTBE. Individuals complained about nausea and dizziness that some believed was linked to MTBE in arctic environments. Alaska promptly suspended implementation of the oxygenated fuels program until health concerns had been investigated. Alaska will require ethanol blended gasoline during its oxygenated fuels season beginning in 1995.⁵³

The results of various studies have been released. A brief summary of their findings are:

- The University of Alaska, Institute of Arctic Biology performed a study on the odor thresholds of MTBE-gasoline blends in Alaska and in the lower-48 States under arctic conditions. According to the study, the base gasoline used in Alaska intensifies the odor detection of MTBE blends. Alaskan gasoline comes from Alaskan north slope refineries and varies in composition from that used in the lower 48 States.⁵⁴
- The American Medical Association issued a recommendation in June 1994 that the use of MTBE be halted until further testing is conducted. Later clarification by the American Medical Association indicated that they were concerned with MTBE use in arctic environments.⁵⁵
- The National Institute for Occupational Safety and Health established that MTBE exposure at retail gasoline outlets was well below established maximum exposure levels of the American Industrial Hygiene Association. Poor ventilation due to the Alaskan cold weather was suggested as a possible cause of problems with MTBE use in Fairbanks and Anchorage.⁵⁶

The EPA has continued to support the use of MTBE as a fuel oxygenate citing the lack of any substantial evidence that MTBE poses a threat to health.

The refining industry has agreed to perform comprehensive health effects testing on TAME.⁵⁷

No major studies have been funded, as of September 1994, on the health effects of ETBE. This is particularly significant because ETBE may play a prominent role in allowing compliance with the ROS during the summer months.

⁵³ "State Intelligence Profiles: Alaska," *21st Century Fuels*, August 1994, p.23.

⁵⁴ "OFA-Funded Study Provides Reason for Alaska MTBE Scare," *Oxy-Fuel News*, August 29, 1994, p. 3.

⁵⁵ "AMA Calls Reports of MTBE Moratorium Request 'Inaccurate'," *Oxy-Fuel News*, July 18, 1994, p. 3.

⁵⁶ "No Link Between MTBE and Health Problems Found," *Oxy-Fuel News*, August 23, 1993, p.1-2.

⁵⁷ "TAME Health Effects Tests to Begin, ETBE Delayed," *Octane Week*, August 1, 1994, p. 5.

Comprehensive chemical inventories of pollutants produced by fuels and fuel additives are required, as are toxicologic data under final regulations on fuels and fuel additives promulgated by EPA in May 1994.⁵⁸ These requirements will provide health effects data, by the year 2000, on over 7000 fuels and fuel additives registered with EPA before the rules were finalized.⁵⁹ New products will be required to have completed inventories and testing prior to registration.⁶⁰ These rules will provide a wealth of information on oxygenates but will require several years before the information is gathered and available.

⁵⁸ *Federal Register*, EPA, June 27, 1994, p.33042-33142.

⁵⁹ "Fuel and Fuel Additive Regulations Finalized by EPA," *Octane Week*, June 13, 1994, p.5.

⁶⁰ *Federal Register*, EPA, June 27, 1994, p.33042-33142.

Glossary

Glossary

Additive Rule: A proposed regulation released by EPA on December 6, 1993 that requires detergent additives to motor gasoline to meet performance-based standards. The final rule is pending as of September 1994.

Additives: Chemicals blended in small amounts into gasoline and other petroleum products to improve performance. Can also be detergent in nature.

Air Toxics: Under the Clean Air Act, total mass emissions of benzene, formaldehyde, acetaldehyde, butadiene, and polynuclear organic material. These are anticipated to cause serious or irreversible chronic or acute health effects in humans.

Alcohol. The family name of a group of organic chemical compounds composed of carbon, hydrogen, and oxygen. The series of molecules vary in chain length and are composed of a hydrocarbon plus a hydroxyl group; $\text{CH}_3\text{-(CH}_2\text{)}_n\text{-OH}$ (e.g., methanol, ethanol, and tertiary butyl alcohol).

Alkylate: The product of an alkylation reaction. It usually refers to the high octane product from alkylation units. This alkylate is used in blending high octane gasoline.

Alkylation: A refining process for chemically combining isobutane with olefin hydrocarbons (e.g., propylene, butylene) through the control of temperature and pressure in the presence of an acid catalyst, usually sulfuric acid or hydrofluoric acid. The product, alkylate, an isoparaffin, has high octane value and is blended with motor and aviation gasoline to improve the antiknock value of the fuel.

API: American Petroleum Institute.

API Gravity: An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API.

Antidumping: The prevention of changes to conventional or non-reformulated gasoline properties by inclusion of products removed from the reformulate process that could increase VOC, NO_x , or TAP emissions.

Aromatics: Hydrocarbons characterized by unsaturated ring structures of carbon atoms. Commercial petroleum aromatics are benzene, toluene, and xylene (BTX).

ASTM: The acronym for the American Society for Testing and Materials.

Atmospheric Crude Oil Distillation: The refining process of separating crude oil components at atmospheric pressure by heating to temperatures of about 600° to 750° F (depending on the nature of the crude oil and desired products) and subsequent condensing of the fractions by cooling.

Attainment Area: An area considered to have air quality as good as or better than the National Ambient Air Quality Standards as defined in the Clean Air Act. An area may be an attainment area for one pollutant and a nonattainment area for others.

Barrel: The standard unit of measurement of liquids in the petroleum industry, containing 42 U.S. gallons at 60 degrees Fahrenheit.

Barrel per Calendar Day: The maximum number of barrels of input that can be processed during a 24-hour period after making allowances for the following limitations:

the capability of downstream facilities to absorb the output of crude oil processing facilities of a given refinery. No reduction is made when a planned distribution of intermediate streams through other than downstream facilities is part of a refinery's normal operation;

the types and grades of inputs to be processed;

the types and grades of products expected to be manufactured;

the environmental constraints associated with refinery operations;

the reduction of capacity for scheduled downtime such as routine inspection, mechanical problems, maintenance, repairs, and turnaround; and

the reduction of capacity for unscheduled downtime such as mechanical problems, repairs, and slowdowns.

Barrels Per Stream Day: The amount a unit can process running at full capacity under optimal crude oil and product slate conditions.

Baseline: Summer and winter gasolines as defined in the 1990 Clean Air Act Amendments or by EPA regulations, for use as a reference for required performance standards for VOC, TAP, and NO_x emissions.

Batch: Homogeneous quantity of petroleum product.

Benzene (C⁶H⁶): An aromatic hydrocarbon present in small proportion in some crude oils and made commercially from petroleum by the catalytic reforming of naphthenes in petroleum naphtha. Also made from coal in the manufacture of coke. Used as a solvent, in manufacturing detergents, synthetic fibers, and petrochemicals and as a component of high-octane gasoline.

Blending Components: See Motor Gasoline Blending Components.

Blending Plant: A facility (including a truck) which has no refining capability but is either capable of producing finished motor gasoline through mechanical blending or blends oxygenates with motor gasoline.

BTX: The acronym for the commercial petroleum aromatics benzene, toluene, and xylene. See individual categories for definitions.

Bulk Terminal: A facility used primarily for the storage and/or marketing of petroleum products which has a total bulk storage capacity of 50,000 barrels or more and/or receives petroleum products by tanker, barge, or pipeline.

Butane (C₄H₁₀): A normally gaseous straight-chain or branch-chain hydrocarbon extracted from natural gas or refinery gas streams. It includes isobutane and normal butane and is designated in ASTM Specification D1835 and Gas Processors Association Specifications for commercial butane.

CARB: California Air Resources Board.

CARB Phase 1 Gasoline: California Air Resources Board regulations set a limit on RVP at 7.80 psi and extend the control period for selected portions of the state beginning in 1992. Detergent additives (subject to certification criteria) to control engine deposits are also required year-round beginning January 1, 1992.

CARB Phase 2 Gasoline: California Air Resources Board reformulated gasoline regulations go into effect statewide and year-round beginning March 1, 1996. California reformulated gasoline regulations will supplant Federal RFG requirements that begin January 1, 1995 for Los Angeles and San Diego. Detergent additive requirements remain in effect.

Captive Refinery Oxygenate Plants: Oxygenate production facilities located within or adjacent to a refinery complex.

Catalytic Cracking: The refining process of breaking down the larger, heavier, and more complex hydrocarbon molecules into simpler and lighter molecules. Catalytic cracking is accomplished by the use of a catalytic agent and is an effective process for increasing the yield of gasoline from crude oil. Catalytic cracking processes fresh feeds and recycled feeds.

Fresh Feeds: Crude oil or petroleum distillates which are being fed to processing units for the first time.

Recycled Feeds: Feeds that are continuously fed back for additional processing.

Catalytic Hydrocracking: A refining process that uses hydrogen and catalysts with relatively low temperatures and high pressures for converting middle boiling or residual material to high-octane gasoline, reformer charge stock, jet fuel, and/or high grade fuel oil. The process uses one or more catalysts, depending upon product output, and can handle high sulfur feedstocks without prior desulfurization.

Catalytic Hydrotreating: A refining process for treating petroleum fractions from atmospheric or vacuum distillation units (e.g., naphthas, middle distillates, reformer feeds, residual fuel oil, and heavy gas oil) and other petroleum (e.g., cat cracked naphtha, coker naphtha, gas oil, etc.) in the presence of catalysts and substantial quantities of hydrogen.

Hydrotreating includes desulfurization, removal of substances (e.g., nitrogen compounds) that deactivate catalysts, conversion of olefins to paraffins to reduce gum formation in gasoline, and other processes to upgrade the quality of the fractions.

Catalytic Reforming: A refining process using controlled heat and pressure with catalysts to rearrange certain hydrocarbon molecules, thereby converting paraffinic and naphthenic type hydrocarbons (e.g., low-octane gasoline boiling range fractions) into petrochemical feedstocks and higher octane stocks suitable for blending into finished gasoline. Catalytic reforming is reported in two categories. They are:

Low Pressure: A processing unit operating at less than 225 pounds per square inch gauge (PSIG) measured at the outlet separator.

High Pressure: A processing unit operating at either equal to or greater than 225 pounds per square inch gauge (PSIG) measured at the outlet separator.

Charge Capacity: The input (feed) capacity of the refinery processing facilities.

Common Carrier: Transportation line or system carrying persons or goods for compensation, impartially for all persons or shippers.

Complex Emissions Model (also called "Complex Model"): A term for the equations describing the relation between fuel properties and regulated emissions. Starting in 1998 and optional before that time, emission performance for gasoline will be calculated by the complex emission model specified by the EPA. The model methodology allows each refinery to vary certain individual parameters to best meet emission standards. The complex model parameters considered are oxygen content, RVP, benzene, aromatics content, sulfur, olefins, and distillation range.

Conventional Gasoline: See Motor Gasoline (Finished).

Distillate Fuel Oil: A general classification for one of the petroleum fractions produced in conventional distillation operations. It is used primarily for space heating, on-and-off-highway diesel engine fuel (including railroad engine fuel and fuel for agricultural machinery), and electric power generation. Included are products known as No. 1, No. 2, and No. 4 fuel oils; No. 1, No. 2, and No. 4 diesel fuels. Distillate fuel oil is reported in the following sulfur categories: 0.05% sulfur and under and Greater than 0.05% sulfur.

Ethanol: See Fuel Ethanol.

ETBE (Ethyl tertiary butyl ether) ((CH₃)₃COC₂H₅): An oxygenate blend stock formed by the catalytic etherification of isobutylene with ethanol.

Ether: A generic term applied to a group of organic chemical compounds composed of carbon, hydrogen, and oxygen, characterized by an oxygen atom attached to two carbon atoms (e.g., methyl tertiary butyl ether).

Federal Implementation Plan (FIP): A plan, or portion thereof, promulgated by the Administrator of EPA to fill a gap or otherwise correct all or part of an inadequacy in a State Implementation Plan, and which contains requisite sections as are required for State Implementation Plans.

Fuel Ethanol (C₂H₅OH): An anhydrous denatured aliphatic alcohol intended for gasoline blending as described in the Oxygenate definition.

Fungibility: Interchangeability, particularly with regard to commingling or mixing of liquids for the purposes of transport or storage.

Gasohol: A blend of finished motor gasoline and alcohol (generally ethanol but sometimes methanol), limited to 10 percent by volume of alcohol.

Gasoline Blending Components: Naphthas which will be used for blending or compounding into finished aviation or motor gasoline (e.g., straight-run gasoline, alkylate, reformat, benzene, toluene, and xylene). Excludes oxygenates (alcohols, ethers), butane, and pentanes plus.

Gasoline Volatility: The properties of gasoline that characterize its tendency to evaporate. Reid Vapor Pressure is a measure of gasoline volatility.

Gravity: A measure of the density, that is the weight per unit volume of petroleum liquid, usually expressed in either degrees API or related to water as a specific gravity.

GTBA: See Oxygenate (Methanol).

Idle Capacity: The component of operable capacity that is not in operation and not under active repair, but capable of being placed in operation within 30 days; and capacity not in operation but under active repair that can be completed within 90 days.

Imports: Receipts of crude oil and petroleum products into the 50 States and the District of Columbia from foreign countries, Puerto Rico, the Virgin Islands, and other U.S. possessions and territories.

Interface: A quantity of petroleum product between two surrounding batches of petroleum product. The interface quantity does not contain the product specifications of either adjoining petroleum product.

Jones Act: Commonly used term for the Merchant Marine Act of 1920 that provides for the protection of the U.S. merchant fleet by excluding foreign-built, owned, or operated ships from the U.S. domestic trades. The Jones Act covers all waterborne transportation between U.S. ports, including inland waterways, Great Lakes, and the oceanborne trade between the U.S. mainland and the noncontiguous areas of Alaska, Hawaii, and Puerto Rico; also designates all vessel personnel, longshoremen, and harbor workers as "seamen" and wards of the Federal court.

Liquefied Petroleum Gases (LPG): Ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids.

Merchant Oxygenate Plants: Oxygenate production facilities that are not associated with a petroleum refinery. Production from these facilities is sold under contract or on the spot market to refiners or other gasoline blenders.

Methanol (CH₃OH): A light, volatile alcohol intended for gasoline blending as described in the Oxygenate definition.

Motor Gasoline (Finished): A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, that has been blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as given in ASTM Specification D4814 or Federal Specification VV-G-1690B, includes a range in distillation temperatures from 122° to 158° F at the 10-percent recovery point and from 365° to 374° F at the 90-percent recovery point. "Motor gasoline" includes reformulated gasoline, oxygenated gasoline, and other finished gasoline. Blendstock is excluded until blending has been completed.

Reformulated Gasoline: Gasoline formulated for use in motor vehicles, the composition and properties of which meet the requirements of the reformulated gasoline regulations promulgated by the U.S. Environmental Protection Agency under Section 211K of the Clean Air Act. Includes oxygenated fuels program reformulated gasoline (OPRG). Excludes reformulated gasoline blendstock for oxygenate blending (RBOB).

Oxygenated Gasoline: Gasoline formulated for use in motor vehicles that has an oxygen content of 1.8 percent or higher, by weight. Includes gasohol. Excludes reformulated gasoline, oxygenated fuels program reformulated gasoline (OPRG) and reformulated gasoline blendstock for oxygenate blending (RBOB).

Other Finished or Conventional Gasoline: Motor gasoline not included in the oxygenated or reformulated gasoline categories.

Motor Gasoline Blending: Mechanical mixing of motor gasoline blending components and oxygenates to produce finished motor gasoline. Mechanical mixing of finished motor gasoline with motor gasoline blending components or oxygenates which results in increased volumes of finished motor gasoline, and/or changes in the classification of finished motor gasoline (e.g., other finished motor gasoline mixed with MTBE to produce oxygenated motor gasoline), is considered motor gasoline blending.

Motor Gasoline Blending Components: Naphthas which will be used for blending or compounding into finished motor gasoline (e.g. straight-run gasoline, alkylate, reformate, benzene, toluene, and xylene) and includes reformulated gasoline blendstock for oxygenate blending (RBOB). Excludes oxygenates (alcohols, ethers), butane, and pentanes plus. Oxygenates are reported as individual components and included in the total for other hydrocarbons, hydrogens, and oxygenates.

MTBE (Methyl tertiary butyl ether) ((CH₃)₃COCH₃): An ether intended for gasoline blending as described in Oxygenate definition.

National Ambient Air Quality Standards (NAAQS): The standards are a set of concentrations of various air-borne substances as required by the Clean Air Act.

Neat: The material prior to blending; e.g., neat ethanol or neat MTBE.

Net Imports: The difference between total imports and total exports.

Net Receipts: The difference between total movements into and total movements out of each PAD District by pipeline, tanker, and barge.

Nonattainment Area: Any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standards for a pollutant or pollutants as determined by EPA.

NO_x: Nitrogen Oxides. Gaseous chemical compounds containing nitrogen and oxygen; reacts with the volatile organic compounds in the presence of heat and sunlight to form ozone. It also contributes to acid rain.

Olefins: A class of unsaturated (open-chain, hydrogen-deficient) paraffinic hydrocarbons recovered from petroleum and characterized by one double bond connecting one carbon atom. The general formula is C_nH_{2n}. Examples are ethylene, propylene, and butylene.

Operable Capacity: The amount of capacity that, at the beginning of the period, is in operation; not in operation and not under active repair, but capable of being placed in operation within 30 days; or not in operation but under active repair that can be completed within 90 days. Operable capacity is the sum of the operating and idle capacity and is measured in barrels per calendar day or barrels per stream day.

Operating Capacity: The component of operable capacity that is in operation at the beginning of the period.

Operable Utilization Rate: Represents the utilization of the atmospheric crude oil distillation units. The rate is calculated by dividing the gross input to these units by the operable refining capacity of the units.

Operating Utilization Rate: Represents the utilization of the atmospheric crude oil distillation units. The rate is calculated by dividing the gross input to these units by the operating refining capacity of the units.

Opt-in: Voluntary commitment of a non-attainment area (or under certain circumstances, attainment areas within a transport region) to join the reformulated gasoline program prior to the specific attainment dates prescribed by the Clean Air Act Amendments of 1990 that are based on severity of ozone pollution. The commitment must come from the Governor of the State as required by the Act.

Other Finished Gasoline: See Motor Gasoline (Finished).

Other Oxygenates: Other aliphatic alcohols and aliphatic ethers intended for motor gasoline blending (e.g., isopropyl ether (IPE) or n-propanol).

Oxygenate: Any substance which, when added to gasoline, increases the amount of oxygen in that gasoline blend. Through a series of waivers and interpretive rules, the Environmental Protection Agency (EPA) has determined the allowable limits for oxygenates in unleaded gasoline. The "Substantially Similar" Interpretive Rules (56 FR (February 11, 1991)) allows blends of aliphatic alcohols other than methanol and aliphatic ethers, provided the oxygen content does not exceed 2.7 percent by weight. The "Substantially Similar" Interpretive Rules also provides for blends of methanol up to 0.3 percent by volume exclusive of other oxygenates, and butanol or alcohols of a higher molecular weight up to 2.75 percent by weight. Individual waivers pertaining to the use of oxygenates in unleaded gasoline have been issued by the EPA. They include:

Fuel Ethanol: Blends of up to 10 percent by volume anhydrous ethanol (200 proof) (commonly referred to as the "gasohol waiver").

Methanol: Blends of methanol and gasoline-grade tertiary butyl alcohol (GTBA) such that the total oxygen content does not exceed 3.5 percent by weight and the ratio of methanol to GTBA is less than or equal to 1. It is also specified that this blended fuel must meet ASTM volatility specifications (commonly referred to as the "ARCO" waiver).

Blends of up to 5.0 percent by volume methanol with a minimum of 2.5 percent by volume cosolvent alcohols having a carbon number of 4 or less (i.e., ethanol, propanol, butanol, and/or GTBA). The total oxygen must not exceed 3.7 percent by weight, and the blend must meet ASTM volatility specifications as well as phase separation and alcohol purity specifications (commonly referred to as the "DuPont" waiver).

MTBE (Methyl tertiary butyl ether): Blends up to 15.0 percent by volume MTBE which must meet the ASTM D4814 specifications. Blenders must take precautions that the blends are not used as base gasolines for other oxygenated blends (commonly referred to as the "Sun" waiver).

Oxygenated Fuels Program Reformulated Gasoline (OPRG): Reformulated gasoline which is intended for use in an oxygenated fuels program control area during an oxygenated fuels program control period.

Oxygenated Gasoline: See Motor Gasoline (Finished).

Ozone: A compound consisting of three oxygen atoms, which is a significant constituent of smog. It is formed through chemical reactions in the atmosphere involving volatile organic compounds, nitrogen oxides, and sunlight.

Petroleum Administration for Defense Districts (PADD): Geographic aggregations of the 50 States and the District of Columbia into five districts by the Petroleum Administration for

Defense in 1950. These districts were originally defined during World War II for purposes of administering oil allocation.

PADD I (U.S. East Coast)

Sub-PADD IA (New England)- Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

Sub-PADD IB (Central Atlantic)- District of Columbia, Delaware, Maryland, New Jersey, New York and Pennsylvania.

Sub-PADD IC (Lower Atlantic)- Florida, Georgia, North Carolina, South Carolina, Virginia and West Virginia.

PADD II (U.S. Midwest)- Indiana, Illinois, Kentucky, Tennessee, Michigan, Ohio, Minnesota, Wisconsin, North Dakota, South Dakota, Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

PADD III (U.S. Gulf Coast)- Texas, Louisiana, Mississippi, Alabama, Arkansas, and New Mexico.

PADD IV (U.S. Rocky Mountain states)- Montana, Idaho, Wyoming, Utah, and Colorado.

PADD V (U.S. West Coast)- Washington, Oregon, California, Nevada, Arizona, Alaska, and Hawaii.

Phase I RVP: EPA regulations (phase 1 of a 2 phase program) that set maximum limits on the summer volatility of motor gasoline to control evaporative emissions, and therefore ozone formation. The regulations were in effect for summer months from June 1989 through the summer of 1991. Phase II RVP regulations supplanted Phase I in 1992.

Phase II RVP: EPA regulations (phase 2 of a 2 phase program) that set maximum limits on the summer volatility of motor gasoline to control evaporative emissions, and therefore ozone formation. The regulations became effective for summer months beginning June 1992 and remain in effect for all areas that are not under other, more stringent, requirements (such as RFG or a SIP-reduced RVP).

Product Compatibility: The ability to mix separate batches of a specific, complying product type with the resulting product remaining on-specification: a quality necessary for the effective operation of the logistics system.

RBOB. "Reformulated Gasoline Blendstock for Oxygenate Blending" is a motor gasoline blending component which, when blended with a specified type and percentage of oxygenate, meets the definition of reformulated gasoline.

Refinery: An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and oxygenates.

Refinery Input, Crude Oil: Total crude oil (domestic plus foreign) input to crude oil distillation units and other refinery processing units (cokers, etc.).

Refinery Input, Total: The raw materials and intermediate materials processed at refineries to produce finished petroleum products. They include crude oil, products of natural gas processing plants, unfinished oils, other hydrocarbons and oxygenates, motor gasoline and aviation gasoline blending components and finished petroleum products.

Refinery Production: Petroleum products produced at a refinery or blending plant. Published production of these products equals refinery production minus refinery input. Negative production will occur when the amount of a product produced during the month is less than the amount of that same product that is reprocessed (input) or reclassified to become another product during the same month. Refinery production of unfinished oils, and motor and aviation gasoline blending components appear on a net basis under refinery input.

Refinery Yield: Refinery yield (expressed as a percentage) represents the percent of finished product produced from input of crude oil and net input of unfinished oils. It is calculated by dividing the sum of crude oil and net unfinished input into the individual net production of finished products. Before calculating the yield for finished motor gasoline, the input of natural gas liquids, other hydrocarbons and oxygenates, and net input of motor gasoline blending components must be subtracted from the net production of finished motor gasoline. Before calculating the yield for finished aviation gasoline, input of aviation gasoline blending components must be subtracted from the net production of finished aviation gasoline.

Reformulated Gasoline: See Motor Gasoline (Finished).

Reformulated Gasoline Credit: The unit of measure for the paper transfer of oxygen or benzene content resulting from reformulated gasoline which contains more than 2.1 weight percent of oxygen or less than 0.95 volume percent benzene.

Reg Neg (Regulatory Negotiation): An agreement in principle, signed August 6, 1991, between environmental, industry, and government representatives, that concluded regulatory negotiation on implementation guidelines of the Clean Air Act Amendments of 1990.

RFG Phase I: The years 1995-1999.

RFG Phase II: The year 2000 and beyond.

Rundown: The depletion of stock in a tank preparatory to its use for another product.

RVP (Reid Vapor Pressure): Typically measured in terms of pounds per square inch (psi); a common measure of fuel volatility, or tendency to evaporate.

Shell Storage Capacity: The design capacity of a petroleum storage tank which is always greater than or equal to working storage capacity.

Simple Model. A certification model used to determine whether RFG meets VOC and TAP reduction standards. Parameters considered are oxygen content, RVP, benzene, and aromatics content.

Spillover: The supply of Clean Air Act-mandated fuels to areas not requiring such material because of limitations on the distribution (logistical) system.

State Implementation Plan (SIP): A statutory requirement of the Clean Air Act, that serves as the official plan of regulatory action that a State will implement to achieve and maintain air quality standards.

Sub-octane: Unfinished gasoline that is specifically formulated to have an octane value below the commonly recognized gasoline grades in order to allow downstream octane enhancement through oxygenate (ethanol) blending. Oxygenate may be blended for its octane properties and/or its oxygen content.

Sulfur: A yellowish nonmetallic element, sometimes known as "brimstone".

T₅₀: Temperature (°F) at which 50 percent of product is distilled away.

T₉₀: Temperature (°F) at which 90 percent of product is distilled away.

TAME (Tertiary amyl methyl ether) ((CH₃)₂(C₂H₅)COCH₃). An oxygenate blend stock formed by the catalytic etherification of isoamylene with methanol.

Tank heels: That residue including water found after marketable product has been withdrawn from a tank.

TBA (Tertiary butyl alcohol) ((CH₃)₃COH): An alcohol primarily used as a chemical feedstock, a solvent or feedstock for isobutylene production for MTBE; produced as a co-product of propylene oxide production or by direct hydration of isobutylene.

TAP (Toxic Air Pollutants): "Toxic Air Pollutants" is defined as the aggregate emissions of: benzene; 1,3 butadiene; polycyclic organic matter (POM); acetaldehyde; and formaldehyde.

Testing Consortium: A group of refining and testing companies established in May 1994 that will perform sampling and testing of finished motor gasoline at the retail level. Results of the tests must comply with the Clean Air Act Amendments of 1990 provisions.

Toluene (C₆H₅CH₃): Colorless liquid of the aromatic group of petroleum hydrocarbons, made by the catalytic reforming of petroleum naphthas containing methyl cyclohexane. A high-octane gasoline-blending agent, solvent, and chemical intermediate, base for TNT.

Transition Periods: Periods before and after seasonal specification changes when product specifications are potentially influenced by logistical constraints (e.g., delivery of oxygenated gasoline prior to its mandated requirement to ensure compliance with the Clean Air Act).

VOC (Volatile Organic Compound): As defined by the Administrator of the Environmental Protection Agency.

Waiver: The EPA can grant waivers from the requirements for oxygenated gasoline in a nonattainment area, based on inadequate domestic supply of or distribution capacity for oxygenated gasoline, or the deleterious effect of oxygenate on other certain air pollutants (NO_x).

Working Storage Capacity: The difference in volume between the maximum safe fill capacity and the quantity below which pump suction is ineffective (bottoms).

Xylene ($\text{C}_6\text{H}_4(\text{CH}_3)_2$): Colorless liquid of the aromatic group of hydrocarbons made the catalytic reforming of certain naphthenic petroleum fractions. Used as high-octane motor and aviation gasoline blending agents, solvents, chemical intermediates. Isomers are metaxylene, orthoxylene, paraxylene.

Acronyms and Abbreviations

Acronyms and Abbreviations

In order to avoid repetition, some of the terms in this report were abbreviated. This list was designed to assist the reader in defining the acronyms and abbreviations frequently mentioned. For a quick reference while reading the report, simply open the fold-out sheet. For a detailed definition of terms, refer to the Glossary.

AAA- American Automobile Association
AEO- *Annual Energy Outlook*
API- American Petroleum Institute
ASTM- American Society for Testing and Materials
Btu- British thermal unit
BTX- benzene, toluene, and xylene
CAAA- Clean Air Act Amendments of 1990
CARB- California Air Resources Board
CG- conventional gasoline
CMSA- Consolidated Metropolitan Statistical Area
CO- carbon monoxide
DOE- Department of Energy
DOT- Department of Transportation
DWT- dead weight tons
EIA- Energy Information Administration
EPA- Environmental Protection Agency
ETBE- ethyl tertiary butyl ether $(CH_3)_3COC_2H_5$
FIP- Federal Implementation Plan
FE- Fuel ethanol (C_2H_5OH)
GATT- General Agreement on Tariffs and Trade
GTBA- gasoline-grade tertiary butyl alcohol
LPG- liquefied petroleum gases
MB- thousand barrels
MBD- thousand barrels per day
MSA- Metropolitan Statistical Area
MTBE- Methyl tertiary butyl ether $(CH_3)_3COCH_3$
NAAQS- National Ambient Air Quality Standards
NEMS- National Energy Modeling System
NGPL- natural gas plant liquid
NO_x- oxides of nitrogen
NPC- National Petroleum Council
NPRA- National Petroleum Refiners Association
OPA- Oil Pollution Act of 1990
OPRG- Oxygenated Fuels Program Reformulated Gasoline
PADD- Petroleum Administration for Defense District
PDVSA- Petroleos de Venezuela S.A.
PSI- pounds per square inch
PTD- product transfer document
RAC- refinery acquisition costs
RBOB- reformulated gasoline blendstock for oxygenate blending
Reg Neg- Regulatory Negotiation
RFG- reformulated gasoline
RFG Phase I- The years 1995-1999
RFG Phase II- The year 2000 and beyond
ROS- Renewable Oxygenate Standard
RVP- Reid vapor pressure
SIP- State Implementation Plan
SPR- Strategic Petroleum Reserve
STEO- *Short Term Energy Outlook*
TAME- tertiary amyl methyl ether $(CH_3)_2(C_2H_5)COCH_3$
TBA- tertiary butyl alcohol $(CH_3)_3COH$
TAP- toxic air pollutants
VOC- volatile organic compound
WPSR- *Weekly Petroleum Status Report*