Demand, Supply, and Price Outlook for Reformulated Motor Gasoline 1995

by Tancred Lidderdale*

Provisions of the Clean Air Act Amendments of 1990 designed to reduce ground-level ozone will increase the demand for reformulated motor gasoline in a number of U.S. metropolitan areas. Reformulated motor gasoline is expected to constitute about one-third of total motor gasoline demand in 1995, and refiners will have to change plant operations and modify equipment in order to meet the higher demand. The costs incurred are expected to create a wholesale price premium for reformulated motor gasoline of up to 4.0 cents per gallon over the price of conventional motor gasoline. This article discusses the effects of the new regulations on the motor gasoline market and the refining industry.

The reformulated motor gasoline provisions of the Clean Air Act Amendments of 1990 (CAAA90) require reductions in automobile emissions of ozone-forming volatile organic compounds (VOC) during the summer high-ozone season and of toxic air pollutants (TAP) during the entire year in certain areas of the United States.[1] The new regulations, which go into effect December 1, 1994, mandate the sale of reformulated motor gasoline in the nine largest metropolitan areas with the highest summer ozone levels and other ozone nonattainment areas that opt in to the program. (Some nonattainment areas with less severe ozone problems will pursue other measures to achieve the required ozone reductions; therefore, there will be no need to sell reformulated motor gasoline in those areas.) The regulations also prohibit motor gasoline sold in the rest of the country from becoming more polluting than it was in 1990. That provision is intended to ensure that refiners do not use ingredients in conventional motor gasoline that can no longer be used in reformulated motor gasoline.

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[1]Public Law 101–549, section 211(k), "Clean Air Act Amendments of 1990" (enacted November 15, 1990). Final rule published in *Federal Register*, Vol. 59, No. 32 (February 16, 1994), p. 7716. VOC exclude methane and ethane. TAP are defined as emissions of benzene, 1,3-butadiene, polycyclic organic matter, formaldehyde, and acetaldehyde in *Federal Register*, Vol. 59, No. 32 (February 16, 1994), p. 7722.

This article both analyzes the new regulations' impact on the motor gasoline market and evaluates the constraints and costs faced by the petroleum refining industry in complying with the new regulations. The forecasts in this article are based on forecasts in the *Short-Term Energy Outlook*,[2] which is published quarterly by the Energy Information Administration. The supply, demand, and price forecasts in this article do not include provisions for a required minimum use of renewable oxygenates, which had been proposed but not yet promulgated by the Environmental Protection Agency (EPA) at the time this article was prepared.[3]

Demand for reformulated motor gasoline is expected to represent almost 35 percent of total motor gasoline demand in 1995. Demand projections for reformulated motor gasoline are based on the 1990 populations of the participating ozone nonattainment areas and projected per capita motor gasoline demand in each area. Corrections are made for spillover of reformulated motor gasoline to areas that will not legally require it, changes in automobile fuel efficiency, and price elasticity of demand.

Refineries will have to change operating procedures, make plant modifications, and obtain new process equipment in order to meet the new oxygenate, vapor-pressure, and benzene specifications and the emissions reduction requirements for reformulated motor gasoline. However, significant disruptions to motor gasoline supply arising from the reformulated motor gasoline regulations are not anticipated.

The minimum oxygenate requirement for reformulated motor gasoline will increase demand for the oxygenates ethanol, methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), and tertiary amyl methyl ether (TAME) (see Glossary box on page 6). Aggregate demand is expected to increase from the 1993 average of 319.1 thousand barrels per day of MTBE-equivalent volume to an average of 480 thousand barrels per day of MTBE-equivalent volume in

[2]Energy Information Administration, *Short-Term Energy Outlook*, Second Quarter 1994, DOE/EIA–0202(94/2Q) (Washington, DC, May 1994).

[3]*Federal Register*, Vol. 58, No. 246 (December 27, 1993), p. 68343. The final rule was announced by EPA on June 30, 1994.

are new, reported LP model results are used to estimate the cost of this part of the reformulated motor gasoline program. The analysis is as follows:

Oxygenate blending. An estimated price premium for oxygenate blending may be derived from the observed premium for oxygenated motor gasoline during the last two winter carbon monoxide control seasons. During the first season (October 1992 to March 1993), the spot price premium for oxygenated motor gasoline over conventional motor gasoline averaged 3.84 cents per gallon for New York harbor cargoes and 3.12 cents per gallon for Gulf Coast waterborne cargoes. Spot price premiums during the second oxygenated motor gasoline season (October 1993 to February 1994) averaged 2.91 cents per gallon in New York and 3.16 cents per gallon on the Gulf Coast.[35]

The wholesale spot price premium for oxygenated motor gasoline above the price of conventional motor gasoline is assumed to rise to 4.0 cents per gallon in 1995. The significant increase in demand for oxygenates in reformulated motor gasoline is assumed to eliminate the oversupply of oxygenates that contributed to weakness in the oxygenates markets. Since the required oxygenate level in reformulated motor gasoline is only 74 percent of the level in oxygenated motor gasoline (2.0 percent by weight versus 2.7 percent by weight), oxygenate blending is assumed to contribute 3.0 cents per gallon to the price premium of reformulated motor gasoline.

RVP reduction. The market price premium for reducing RVP depends on the price differential between motor gasoline and normal butane. The market price premium for 7.8 RVP motor gasoline relative to 9.0 RVP motor gasoline during the summer of 1993 was about 4 percent of the price difference between 7.8 RVP motor gasoline and normal butane, or about 0.66 cent per gallon per psi reduction.[36] This observed market price premium was almost 50 percent greater than expected from a simple linear blend calculation that corrects for octane differences. One reason for the additional price premium for low RVP motor gasoline was that 7.8 RVP material is required only in ozone nonattainment areas in the southern United States, which represented only about 18 percent of the total motor gasoline market. The small market share and restrictive distribution requirements may have contributed to the higher observed market price premium.

The reformulated motor gasoline regulations require a 0.9-psi reduction in RVP in northern U.S. ozone nonattainment areas and a 0.6-psi reduction in southern areas during the summer months. The average reformulated motor gasoline RVP reduction is about 0.8 psi. EPA estimates the refinery cost to reduce RVP (including capital recovery cost) at about 0.4 cent per gallon per psi reduction.[37] This estimate is consistent with the observed market price premium in June and July 1993, when demand for low-RVP motor gasoline was at its highest. EIA estimates the average cost for reducing RVP to meet reformulated motor gasoline requirements during the summer months to be about 0.4 cent per gallon of reformulated motor gasoline (0.8 psi multiplied by 0.5 cent/gallon/psi reduction).

Aromatics reduction. The average level of aromatics in regular unleaded motor gasoline was about 32 percent by volume in the summer and 28 percent by volume during the winter. Benzene concentrations averaged 1.6 percent by volume during the summer and 1.5 percent during the winter.[38] Under the new regulations, benzene must be reduced to 1.0 percent by volume or lower. The required aromatics reduction is determined by the emissions model for TAP reduction and is dependent on the fuel's RVP, benzene concentration, and the level and type of oxygenate. Reductions in aromatics of 2 to 4 percent by volume are expected.

EPA estimates the cost to reduce aromatics from 30 percent to 28 percent by volume to be 0.07 cent per gallon for each percent reduction. For a further reduction from 28 to 24 percent, the cost rises to 0.31 cent per gallon for each percent reduction.[39] EIA assumes an average cost of benzene and aromatics reduction of 0.50 cent per gallon.

By these analyses, EIA estimates that blending oxygenates to yield 2.0 percent oxygen by weight will cost 3.0 cents per gallon. Removing high-vapor-pressure components (to meet summer RVP specifications) and reducing levels of benzene and other aromatics will cost 0.40 cent per gallon and 0.50 cent per gallon, respectively. Therefore, the total added cost of reformulated motor gasoline is estimated to be 3.9 cents per gallon in summer and 3.5 cents per gallon in winter.

[35]McGraw-Hill, Inc., *Platt's Oilgram Price Report*, Price Average Supplement, February 1994, Vol. 71, No. 59 (New York, NY, March 25, 1994), p. 2, and earlier issues

[36]McGraw-Hill, Inc., *Platt's Oilgram Price Report*, Price Average Supplement, August 1993, Vol. 71, No. 234 (New York, NY, December 3, 1993), p. 2, and earlier issues.

[37]Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (Washington, DC, December 13, 1993), p. 348.

[38]National Institute for Petroleum and Energy Research, *Motor Gasolines, Winter 1991-92*, NIPER–175 PPS 92/3 (Bartlesville, OK, June 1992), pp. 77–80, and *Motor Gasolines, Summer 1992*, NIPER–178 PPS 93/1 (Bartlesville, OK, January 1993), pp. 75–78.

[39]Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (Washington, DC, December 13, 1993), pp. 348, 403.

1995. New oxygenate domestic production capacity and imports should be adequate to satisfy this demand surge.

Refiners will incur higher operating and capital costs in producing reformulated motor gasoline. The costs of oxygenate blending, lower motor gasoline vapor pressure, and reduced benzene and aromatics concentrations are expected to yield a reformulated motor gasoline wholesale price premium of 3.5 to 4.0 cents per gallon above the price of conventional unleaded motor gasoline. The retail price premium may be greater due to testing and compliance costs and to the costs of handling and transporting the additional grades of motor gasoline, which must be segregated in the distribution system. In addition, the wider use of oxygenates, which have a lower energy content than the motor gasoline components they displace, will raise consumers' effective final costs by imposing fuel economy penalties.

Program Requirements

Minimums. As of January 1, 1995, all reformulated motor gasoline at retail outlets[4] must:

- Contain at least 2.0 percent oxygen by weight (equivalent to 11.2 percent MTBE, or 5.5 percent ethanol, by volume)
- Contain 1.0 percent or less benzene by volume
- Contain no heavy metals, including lead or manganese
- Produce no greater emissions of nitrogen oxides (NO_X) during combustion than a specified baseline motor gasoline, as demonstrated by tests in 1990 model-year automobiles.

Emission reduction targets. In addition, reformulated motor gasoline must meet new VOC and TAP emissions reduction targets, which will be implemented in two phases. (California is imposing its own requirements; see below.) The Phase I regulations, effective from 1995 to 1999, require a reduction of at least 15 percent in VOC and TAP emissions compared with those from 1990 model-year automobiles burning a specified baseline motor gasoline. The VOC emissions reduction is required only during the summer high-ozone season (June 1 to September 15). The TAP emissions reduction requirement applies year-round. (The Phase II emission performance standards will take effect in 2000 and will require additional reductions in VOC, TAP, and NO_X emissions. They are not discussed in this article.)

Phase I will be implemented in two stages. The first stage uses a "simple" certification model to determine whether reformulated motor gasoline meets the VOC and TAP reduction standards. That model relates motor gasoline composition to VOC and TAP emissions and considers only the effects of motor gasoline oxygen content, Reid vapor pressure (RVP), benzene, and aromatics content. Reformulated motor gasoline satisfying the minimum specifications mentioned earlier and the following additional composition requirements will meet the Phase I simple-model NO_X, VOC, and TAP emissions performance standards.

- Oxygen content is limited to no more than 2.7 percent by weight during the summer high-ozone season and 3.5 percent by weight at other times. States can elect to apply the 2.7-percent limit during the winter if the use of higher oxygenate levels is found to cause other air quality problems.
- Reid Vapor Pressure is limited to no more than 7.2 pounds per square inch (psi) in southern areas (EPA VOC Control Region 1) and 8.1 psi in northern areas (EPA VOC Control Region 2) during the high-ozone season of June 1 through September 15. RVP controls also apply May 1 through May 31 for facilities upstream of retail outlets, such as refineries, pipelines, and terminals.
- Aromatics content is determined by the emissions model for the required TAP reductions.
- Each refiner's annual average levels of sulfur and olefins and the temperature at which 90 percent of the fuel vaporizes (T_{90}) must not exceed their 1990 averages.

In the second stage, a "complex model" will supplant the simple model on January 1, 1998. The complex model expands the number of variables that refiners can control to produce qualifying reformulated motor gasoline, including sulfur, olefins, and distillation range. This additional flexibility is expected to provide a more cost-effective method for complying with the emissions reduction requirements. Refiners may also use the complex model during the first stage to show that their fuels meet the emissions standards. However, because it would require segregation of the affected blends in the motor gasoline distribution system and at retail outlets, this option is expected to be used by very few refineries.

California has established its own statewide motor gasoline composition standards that take effect on March 1, 1996. The California Air Resources Board (CARB) regulations are more stringent than those of the Federal Phase I reformulated motor gasoline program. The CARB specifications, to which every gallon of motor gasoline sold in California must conform, are as follows:[5] aromatics content, 25 percent by volume maximum; olefin content, 6 percent by volume maximum; Reid vapor pressure, 7.0 psi summer maximum; sulfur content, 40 parts per million maximum; oxygen content, 1.8 to 2.2 percent by weight; T_{50} (the temperature at which 50 percent of the fuel vaporizes), 210 °F maximum; and T_{90}, 300 °F maximum.

From January 1, 1995, to March 1, 1996, the Federal standards will apply to those California ozone nonattainment areas that are required by the CAAA90 to participate in the reformulated motor gasoline program.

Antidumping provision. CAAA90 includes a regulation requiring that each refiner's or importer's conventional motor gasoline shall not produce any more exhaust benzene

[4] Reformulated motor gasoline requirements apply at facilities upstream of retail outlets, such as refineries, pipelines, and terminals, beginning on December 1, 1994.

[5] *Federal Register*, Vol. 58, No. 37 (February 26, 1993), pp. 11745-50.

emissions than those produced on average by each firm's motor gasoline in 1990. Sulfur, olefins, and T_{90} are capped at 125 percent of each firm's 1990 average. This provision is intended to prevent refiners from using the benzene extracted from the reformulated motor gasoline pool in their conventional motor gasoline. Importers lacking 1990 motor gasoline quality data with which to establish an individual baseline will be required to meet baseline motor gasoline specifications established by the CAAA90 and EPA.

Averaging and credit trading provisions. Refiners and importers will have the option of meeting the requirements for oxygen and benzene content and VOC and TAP emissions reductions on the basis of an average of all motor gasoline output over time rather than on a per-gallon basis. However, the averaging program will require that all refined or imported reformulated motor gasoline that does not meet the standards on a per-gallon basis must meet more stringent standards over an averaging period. For example, the RVP specification is lowered by 0.1 psi and the oxygen requirement is raised by 0.1 percent for refiners who wish to take advantage of averaging. Credits for oxygen and benzene content (but not VOC or TAP) may be purchased from other parties to meet the standards for these parameters.

Reformulated Motor Gasoline Demand

Projections of reformulated motor gasoline demand generally begin with estimates of baseline demand for motor gasoline in areas where CAAA90 mandates the sale of reformulated motor gasoline and other areas that opt in to the reformulated motor gasoline program. Baseline demand estimates are based on 1990 population counts and projected per capita motor gasoline demand and are adjusted for factors that may alter demand, including spillover (delivery of reformulated motor gasoline to areas that do not require it under the regulations), changes in automobile fuel efficiency with reformulated motor gasoline, and price elasticity of demand.

The baseline demand for reformulated motor gasoline (primarily from the nonattainment areas in the Northeast, the Midwest, Texas, and California, which contain about 35 percent of the U.S. population) represents 32.5 percent of total U.S. motor gasoline demand. The net effect of spillover, changes in fuel efficiency, and demand responses to price are projected to increase the total reformulated motor gasoline market share to about 34.4 percent of total motor gasoline demand (Table 1). This projection is consistent with the results from the 1992 National Petroleum Council survey of refineries. The survey's 121 respondents (representing about 86 percent of U.S. crude oil atmospheric distillation capacity) expect

Table 1. Population, 1990, and Reformulated Motor Gasoline Demand Shares by Petroleum Administration for Defense (PAD) Sub-District, 1995

	Population in Reformulated Motor Gasoline Marketing Areas (percent of total)			Motor Gasoline Demand 1995 (thousand barrels per day)	
PAD Sub-District	Mandated Areas	Opt-In Areas	Total	Total	Reformulated
IA — New England	15.5	74.8	90.3	373	337
IB — Central Atlantic	58.5	26.9	85.3	1,083	924
IC — Lower Atlantic	0.0	9.8	9.8	1,262	123
II — Midwest	13.6	1.4	15.0	2,254	338
III — Gulf Coast	11.8	11.2	23.0	1,079	248
IV — Rocky Mountain	0.0	0.0	0.0	241	0
V — West Coast (ex CA)	0.0	0.0	0.0	460	0
V — California (only)	57.2	0.0	57.2	902	516
U.S. Average and Total	**23.3**	**12.0**	35.3	**7,654**	**2,486**
Spillover to Non-Required Areas (5 percent)[a]	—	—	—	—	126
Reduced Automobile Fuel Efficiency (1.6 percent)[b]	—	—	—	42	42
Price Elasticity of Demand (0.6 percent)[c]	—	—	—	(16)	(16)
Total Motor Gasoline Demand	—	—	—	**7,680**	**2,638 (34.4 percent)[d]**

[a] The Energy Information Administration (EIA) assumes spillover to be 5 percent of the total of reformulated motor gasoline demand and reduced automobile fuel efficiency values minus 5 percent of price elasticity of demand.

[b] EIA estimates reduced automobile fuel efficiency to be 1.6 percent of the total of reformulated motor gasoline demand and spillover.

[c] EIA estimates price elasticity of demand to be 0.6 percent of the total of reformulated motor gasoline demand and spillover.

[d] Percentage share calculated by using unrounded data.

— = Not applicable.

Sources: Federal Highway Administration, *Highway Statistics 1992*, FHWA–93–023 (Washington, DC, 1993), p. 10. Energy Information Administration, *Short-Term Energy Outlook*, Second Quarter 1994, DOE/EIA–0202 (94/2Q) (Washington, DC, May 1994), p. 28.

to produce 7,291 barrels per day of motor gasoline in 1995, of which 36.2 percent is expected to be reformulated.[6]

The sale of reformulated motor gasoline is required in the nine largest metropolitan areas that have the most severe summertime ozone pollution problems (as determined by degree of noncompliance with ozone air quality standards from 1987 through 1989). Those nine ozone nonattainment areas contain over 23 percent of the total U.S. population (Table 2).

The sale of reformulated motor gasoline is also required in 35 additional nonattainment cities, counties, or entire States that have opted in to the reformulated motor gasoline program. The reformulated motor gasoline requirements will apply to those areas on January 1, 1995, or 1 year after an application is received by EPA, whichever is later. As noted above, EPA may delay a State's petition to opt in to the program for up to 3 years if the domestic capacity to produce reformulated motor gasoline is determined to be insufficient. EPA has published opt-in applications from 13 States and the District of Columbia,[7] areas which collectively contain about 12 percent of the total U.S. population (Table 3).

Further, another 51 cities or counties (excluding California) are ozone nonattainment areas and are eligible to opt in to the reformulated motor gasoline program (Table 4).

[6]National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), pp. N238-N240. Response to the NPC survey was as high as 154 of 197 refineries, a total which represented almost 95 percent of 1990 U.S. refinery inputs. Not all respondents answered all survey items.

[7]*Federal Register*, Vol. 59, No. 32 (February 16, 1994), pp. 7807–7808 and 7851–7852.

Table 2. Population of Reformulated Motor Gasoline Program Mandated Areas, 1990

City	EPA VOC Control Region	PAD Sub-District	Population (thousands)
Hartford, CT	2	IA	1,086
New York, NY–NJ–CT	2	IA, IB	18,087
Philadelphia, PA–NJ–DE–MD	2	IB	6,010
Baltimore, MD	1	IB	2,382
Chicago, IL–IN–WI	2	II	8,066
Milwaukee-Racine, WI	2	II	1,607
Houston-Galveston-Brazoria, TX	1	III	3,731
Los Angeles-Anaheim-Riverside, CA	1	V	14,532
San Diego, CA	1	V	2,498
Total Population, Ozone Nonattainment Mandated Areas	—	—	**57,999**
Total U.S. Population, 1990 Census	—	—	**248,710**

— = Not applicable.

Sources: *Federal Register*, Vol. 59, No. 32 (February 16, 1994) pp.7808, 7851. National Petroleum Council, *U.S. Petroleum Refining*, Vol. IV Part 1 (Washington, DC, August 1993), pp. L.III.5-8–L.III.5-30. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States 1992* (112th Edition) (Washington, DC, 1992), pp. 20, 30–32.

However, rather than do so, some States are considering alternatives for reducing local ozone levels. One leading option is to apply only the low-RVP requirement of the reformulated motor gasoline program.[8] Because of the required 1-year delay between application to opt in to the reformulated motor gasoline program and actual participation, those potential opt-in areas are not included in 1995 reformulated motor gasoline demand projections.

Spillover is also expected to contribute to demand for reformulated motor gasoline. Spillover occurs because the geographic definitions of reformulated motor gasoline marketing areas do not coincide with normal distribution patterns; many pipelines and terminals serve areas that require reformulated motor gasoline and those that do not. The expected price differential between reformulated and conventional motor gasoline should provide a strong incentive for refiners and marketers to minimize spillover. Experience gained from the oxygenated motor gasoline program during the winter of 1992–1993 indicates that spillover rates as low as 2.0 percent are possible.[9] EIA assumes a reformulated motor

[8]Hart Publications, Inc., "As SIP Deadline Nears, States Consider Various Options," *Oxy-Fuel News* (November 8, 1993), pp. 8–11.

[9]Charles Dale, "The Economics of the Clean Air Act Amendments of 1990: Review of the 1992-1993 Oxygenated Motor Gasoline Season," Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA–0109(93/07) (Washington, DC, July 1993), p. xvi.

Table 3. Population of Reformulated Motor Gasoline Program Opt-In Areas, 1990

State	EPA VOC Control Region	PAD Sub-District	Opt-In Population (thousands)
Connecticut	2	IA	1,240
Maine	2	IA	809
Massachusetts	2	IA	6,016
New Hampshire	2	IA	806
Rhode Island	2	IA	1,003
Delaware	2	IB	113
District of Columbia	1	IB	607
Maryland	1	IB	1,807
New Jersey	2	IB	411
New York	2	IB	2,471
Pennsylvania	2	IB	6,331
Virginia	1	IC	3,663
Kentucky	2	II	1,029
Texas	1	III	3,560
Total Population, Ozone Nonattainment Opt-In Areas	—	—	**29,868**

— = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: *Federal Register*, Vol. 59, No. 32 (February 16, 1994) pp.7807–7808, 7851. National Petroleum Council, *U.S. Petroleum Refining*, Vol. IV Part 1 (Washington, DC, August 1993), pp. L.III.5-8–L.III.5-30. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States 1992* (112th Edition) (Washington, DC, 1992), pp. 20, 30–32.

gasoline spillover rate of 5.0 percent of baseline demand (126 thousand barrels per day).[10]

With the switch to reformulated motor gasoline, automobile fuel efficiency is expected to decline slightly (and thus affect demand) because the energy (Btu) content of oxygenates is lower than that of the conventional motor gasoline or octane blendstocks (e.g., aromatics) that the oxygenates will displace. This loss will be offset partially by the lower summer RVP requirement, which will reduce both evaporative emissions and the volume of butane, which is low in energy content, in motor gasoline.

Reformulated motor gasoline with MTBE as the oxygenate has a Btu value that is 1.7 percent lower than conventional motor gasoline, while motor gasoline oxygenated with ethanol has a Btu content that is about 1.3 percent lower than conventional motor gasoline.[11] EIA assumes a reduction in fuel efficiency of 1.6 percent due to the use of oxygenates, an assumption which is consistent with EPA's estimate of a 2-percent reduction that will be offset by a 0.3-percent increase from lower RVP values.[12]

Finally, because motor gasoline demand is relatively inelastic with respect to price, the demand for reformulated motor gasoline is projected to be affected only modestly by its price premium. EIA estimates the short-term price elasticity of motor gasoline demand to be about -0.11, so that a 5.0-percent increase in the price of motor gasoline will lead to a 0.6-percent reduction in motor gasoline demand.[13] Assuming an average demand in 1995 for reformulated motor gasoline of 2.6 million barrels per day, a 5.0-percent increase in motor gasoline price in reformulated motor gasoline market areas will reduce demand by only about 16 thousand barrels per day.

Reformulated Motor Gasoline Supply

Although production of reformulated motor gasoline will require significant changes to refinery operations and capital investment of up to $4 billion,[14] there is little reason to believe that the domestic industry will be unable to meet demand in 1995. As of December 1993 (the latest official published statement), EPA had not received any petitions from outside parties to delay implementation of the reformulated motor gasoline program and believed that there would be more than sufficient supply, given the current level of opt-ins.[15]

Domestic refiners must change operations to produce reformulated motor gasoline with reduced benzene and aromatics content, lower RVP specifications, and added oxygenates. (Foreign refiners face different requirements and have different options; see below.)

Domestic refiners have several options for reducing the benzene and aromatics content. The most commonly pursued options focus on the two largest sources of benzene and aromatics in a refinery, which are the fluid catalytic cracker (FCC) and the reformer. FCC motor gasoline contains about 29 percent aromatics by volume and makes up about 41 percent of the total motor gasoline pool. Reformer product (reformate) contains about 66 percent aromatics and makes up about 27 percent of the total motor gasoline pool.[16]

FCC's and reformers are operated to produce high-octane blendstocks for the motor gasoline pool. Changing operating

[10]Respondents to the 1992 NPC refinery survey anticipate a spillover rate of under 5 percent; see National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), p. N261. EPA assumed a 10-percent spillover rate in its regulatory impact analysis; see Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (Washington, DC, December 13, 1993), p. 334.

[11]EIA calculations based on blending component heating values reported by American Petroleum Institute, *Alcohols and Ethers: A Technical Assessment of Their Applications as Fuel and Fuel Components*, Publication 4261, Second Edition (Washington, DC, July 1988), p. 2.

[12]Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (December 13, 1993), pp. 346–347.

[13]EIA calculates the price elasticity of motor gasoline demand by dividing the percentage difference in motor gasoline demand from the *Short-Term Energy Outlook*'s low oil price and high oil price cases by the percentage difference in motor gasoline prices in those two price cases. The elasticity based on the *Short-Term Energy Outlook*, Second Quarter 1994, is 11.0 percent for 1995 average motor gasoline demand.

[14]Respondents to the NPC survey estimated that capital expenditures directly related to reformulated motor gasoline would total $3,979 million. National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), p. N255.

[15]Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (Washington, DC, December 13, 1993), p. 479. Testimony of Susan F. Tierney, Assistant Secretary for Policy, Planning, and Program Evaluation, U.S. Department of Energy, before the Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, U.S. House of Representatives, June 22, 1994.

[16]National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), pp. N242–N244. Numbers have been corrected for normal butane and oxygenate blending.

Table 4. Population of Potential Reformulated Motor Gasoline Program Opt-In Areas by Petroleum Administration for Defense (PAD) Sub-District, 1990

PAD Sub-District	Potential Opt-In Area Population (thousands)	Population (percent of total)
IA — New England	0	0.0
IB — Central Atlantic	0	0.0
IC — Lower Atlantic	12,385	33.0
II — Midwest	24,325	34.1
III — Gulf Coast	2,734	8.6
IV — Rocky Mountain	1,072	14.7
V — West Coast (ex CA)	6,414	45.0
V — California (only)	0	0.0
U.S. Total or Average	**46,929**	**18.9**

Notes: • California has established its own motor gasoline composition standards that take effect statewide in 1996. Thus, PADD V California nonattainment cities are not expected to opt-in to the federal reformulated gasoline program and are not included in this table. • Ozone attainment areas that are within an ozone transport region may also opt in to the program. However, those areas are not included in this table. • Totals may not equal sum of components due to independent rounding.

Sources: *Federal Register*, Vol. 59, No. 32 (February 16, 1994) p.7808, 7851; National Petroleum Council, *U.S. Petroleum Refining*, Vol. IV Part 1 (Washington, DC, August 1993), pp. L.III.5-8–L.III.5-30. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States 1992* (112th Edition) (Washington, DC, 1992), pp. 20, 30–32. *Federal Register*, Vol. 56, No. 21 (November 6, 1991), pp. 56694–56858.

Glossary

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; CH_3-$(CH_2)_n$-OH (e.g., methanol, ethanol, and tertiary butyl alcohol).

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

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 motor gasoline boiling range fractions) into petrochemical feedstocks and higher octane stocks suitable for blending into finished motor gasoline.

ETBE (Ethyl Tertiary Butyl Ether), $(CH_3)_3COCO_2H_5$: An oxygenate blendstock formed by the catalytic etherification of isobutylene with ethanol.

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

Fluid 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 motor gasoline from crude oil.

Isobutylene, C_4H_8: An olefinic compound recovered from refinery processes or petrochemical processes.

TAME (Tertiary Amyl Methyl Ether), $(CH_3)_2(C_2H_5)COCH_3$: An oxygenate blendstock formed by the catalytic etherification of isoamylene with methanol.

conditions (e.g., temperature, pressure, reactor space velocity, catalyst type, etc.) can lower benzene and aromatics production. Based on the 1992 NPC survey data, EIA estimates that about 300 thousand barrels per day of high-pressure catalytic reforming capacity will be converted to low-pressure or continuous-catalyst regeneration units.[17]

Changing the operating conditions of existing equipment, however, will not be enough to satisfy the new motor gasoline quality targets at many refineries; consequently, those refineries are implementing other capital-intensive options to meet the benzene and aromatics restrictions. The options include the use of feed or product distillation to remove benzene and aromatics for subsequent processing.[18] Respondents to the 1992 NPC survey reported plans to install, by 1995, an additional 1.2 million barrels per day of secondary motor gasoline fractionation capacity, 142 thousand barrels per day of pentane/hexane isomerization capacity, 33 thousand barrels per day of light naphtha/motor gasoline aromatics saturation capacity, and 24 thousand barrels per day of additional aromatics extraction capacity.[19]

The new summer RVP regulations continue reductions that began in 1989 with a two-phase RVP reduction program promulgated by the EPA.[20] The reformulated motor gasoline regulations require RVP reductions during the summer months from 9.0 to 8.1 psi in the northern United States (EPA VOC Control Region 2) and from 7.8 to 7.2 psi in the southern United States (EPA VOC Control Region 1).

Controlling the vapor pressure of ordinary motor gasoline is relatively straightforward. The primary methods for lowering RVP are to reduce the volume of normal butane (a liquefied petroleum gas) that is blended into motor gasoline or to increase the volume of normal butane that is rejected from motor gasoline through distillation. About 2 gallons of normal butane have to be removed from 100 gallons of motor gasoline to reduce motor gasoline RVP by 1.0 psi.[21] Butane removed from the motor gasoline pool can be inventoried for winter motor gasoline blending, converted to isobutane and then to isobutylene for MTBE production, or sold in the petrochemicals market.

RVP reduction in reformulated motor gasoline is more difficult because blending with ethanol or MTBE raises the RVP.[22] In addition to reducing normal butane volume, RVP reductions may be obtained by removing C_4 and C_5 olefins (e.g., butylenes and amylenes) from the motor gasoline pool. Alkylation is a primary means of converting light olefins to heavier motor gasoline blendstocks. NPC survey respondents reported plans for an additional 79 thousand barrels per day of alkylation capacity.[23] Isobutylene and isoamylene may also be converted to MTBE/ETBE and TAME, respectively.

Motor gasoline imports averaged 197 thousand barrels per day in 1993, with Brazil, Canada, Saudi Arabia, and Venezuela providing over 71 percent of the total.[24] Over 90 percent of U.S. motor gasoline imports were distributed in PAD District I, the East Coast, which also will be the largest market for reformulated motor gasoline.

Imported reformulated motor gasoline presents a unique problem because offshore refiners could realize a cost advantage

[17]National Petroleum Council, *U.S. Petroleum Refining*, Volume I (Washington, DC, August 1993), p. N236.

[18]A. Goelzer and others, "Refiners Have Several Options for Reducing Gasoline Benzene," *Oil and Gas Journal* (September 13, 1993), pp. 63–69.

[19]National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), pp. N210–N231.

[20]Phase I motor gasoline volatility regulations were announced by Environmental Protection Agency in *Federal Register*, Vol. 54, No. 54 (March 22, 1989) pp. 11868–11869. Phase II volatility regulations were announced in *Federal Register*, Vol. 55, No. 112 (June 11, 1990), pp. 23658–23659.

[21]EIA calculation based on lowering the RVP of finished motor gasoline from 9.0 psi to 8.0 psi by removing normal butane with an RVP of between 55 psi and 60 psi.

[22]U.S. Department of Energy, Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 11*, ORNL–6649 (Oak Ridge, TN, January 1991), p. 4-4.

[23]National Petroleum Council, *U.S. Petroleum Refining*, Volume VI (Washington, DC, August 1993), p. N226.

[24]Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA–0109(94/02) (Washington, DC, February 1994), p. 82. Import figures are adusted to exclude the Virgin Islands.

by dumping benzene and aromatics extracted from reformulated motor gasoline into conventional motor gasoline sold in their own markets and the EPA would be unable to enforce the antidumping regulations. (A cost advantage may arise because foreign refiners may not need to install the same aromatic extraction and conversion capacity that domestic refiners will find necessary.) Under the simple model, the cost advantage is limited to benzene and aromatics and is likely to be small. The cost advantage under the complex model could be larger because of the ability to trade reformulated motor gasoline characteristics, such as aromatics for oxygen content.

Both domestic refiners and importers must establish individual 1990 antidumping baselines for conventional motor gasoline (and levels for sulfur, olefins, and T_{90} in reformulated motor gasoline under the simple model) if the necessary 1990 motor gasoline quality data are available. If not, domestic refiners must use the next best available data from production after 1990. Importers, however, are not allowed to revert to more recent data. If 1990 motor gasoline quality data are not available, importers (and blenders) must use the CAAA90 statutory baseline motor gasoline, which approximates the U.S. national average quality for motor gasoline sold in 1990. However, if an importer brought 75 percent or more of the 1990 motor gasoline production from one refinery into the United States, it must establish an individual baseline as if it were a domestic refinery.

Oxygenate Supply and Demand

EIA projects that demand for oxygenates (ethanol, MTBE, ETBE, and TAME) will increase from an average 319 thousand barrels per day of MTBE-equivalent volume in 1993 to an average 480 thousand barrels per day MTBE-equivalent volume in 1995.[25] (The 1995 demand projections represent the sum of oxygenate demand in the oxygenated and reformulated motor gasoline markets, gasohol blending, and octane blending.) The increase in oxygenate demand for reformulated motor gasoline will be partially offset by expected declines in ethanol blended into gasohol and MTBE blended into conventional motor gasoline. Oxygenate supply in 1995 will come primarily from MTBE and fuel ethanol domestic production and will be supplemented by small volumes of TAME and ETBE production, MTBE imports, and MTBE inventory drawdown.

Total oxygenate demand is based on projections of reformulated and oxygenated motor gasoline demand, plus continued demand for ethanol and MTBE as blendstocks in conventional motor gasoline. EIA expects demand for oxygenates for use in reformulated and oxygenated motor gasoline to average 373 thousand barrels per day of MTBE-equivalent volume in 1995. Continued demand for ethanol in gasohol blending and MTBE as a motor gasoline octane blendstock will make up the balance of the total projected oxygenate demand in 1995 (Figure 1).

[25]Oxygenate demand for 1993 from Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA–0109(94/01) (Washington, DC, January 1994), pp. 148, 149.

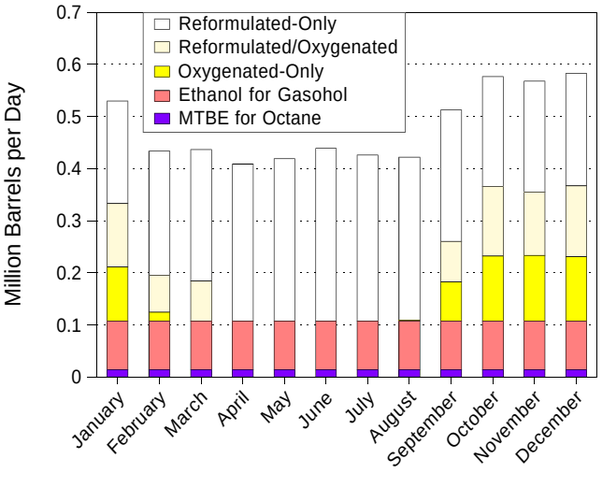
The oxygenate content of reformulated motor gasoline is assumed to average 2.1 percent by weight. EPA's oxygenated motor gasoline program (which went into effect on November 1, 1992) requires the reformulated motor gasoline markets in Baltimore, New York, Philadelphia, Washington, DC, and the State of New Jersey to increase the oxygenate level to a minimum 2.7 percent by weight (2.8 percent by weight assumed average) during certain winter months.[26] An additional 21 cities participating in the oxygenated motor gasoline program continue to require 2.7 percent oxygenates by weight, except all cities in California (2.1 percent by weight assumed) and Tucson, Arizona (1.9 percent by weight assumed).[27] EIA projects 1995 average oxygenate demands (in MTBE-equivalent volume) in these markets to be as follows: reformulated-only markets, 263 thousand barrels per day; reformulated/oxygenated markets, 62 thousand barrels per day; and oxygenated-only markets, 48 thousand barrels per day. The projected total nonattainment area oxygenate demand is 373 thousand barrels per day.

Ethanol will continue to be used for gasohol in areas that do not require reformulated or oxygenated motor gasoline. Over 76 percent of all gasohol is sold in the midwestern States (PAD District II) because of proximity to ethanol producers and State tax incentives for gasohol. Ethanol demand averaged about 68 thousand barrels per day during the second and third quarters of 1993 (between the first and second oxygenated motor

[26]Those markets require motor gasoline to meet both the reformulated and oxygenated specification requirements and are designated as reformulated/oxygenated markets.

[27]For a review of the oxygenated motor gasoline forecast procedure, refer to Tancred Lidderdale, "Demand, Supply, and Price Outlook for Oxygenated Gasoline, Winter 1992-1993," Energy Information Administration, *Monthly Energy Review*, DOE/EIA–0035(92/08) (Washington, DC, August 1992), p. 7.

Figure 1. Projected Oxygenate Demand, 1995



Source: Author's calculations based on Energy Information Administration, *Short-Term Energy Outlook*, Second Quarter 1994, DOE/EIA–0202(94/Q) (Washington, DC, May 1994), p. 28.

gasoline seasons).[28] This historical baseline ethanol demand for gasohol blending is lowered to account for reformulated and oxygenated motor gasoline market shares in States that reported gasohol sales.[29] About 120 thousand barrels per day of gasohol (12 thousand barrels per day of ethanol, which makes up 10 percent of gasohol) may be replaced by reformulated or oxygenated motor gasoline.

The new demand for oxygenates should push total demand closer to total oxygenate production capacity, leading to stronger oxygenate prices. Those higher prices will probably lead to reduced gasohol sales in States without tax credits or instate ethanol production facilities. About 20 thousand barrels per day of ethanol were sold in States without tax credits for gasohol blending in 1992. This forecast assumes that an additional 10 thousand barrels per day of ethanol will be redirected from gasohol sales to reformulated motor gasoline markets. The continued demand for ethanol in gasohol sales is then projected to average 46 thousand barrels per day (93 thousand barrels per day MTBE-equivalent volume).

MTBE may also continue to be used as an octane blend component in motor gasoline sold in areas that do not require reformulated or oxygenated motor gasoline. MTBE demand averaged about 88 thousand barrels per day during the second quarter of 1993. Due to excess MTBE production capacity during 1993, MTBE selling prices were generally determined by their octane values and did not include any oxygenate price premiums. Thus, there was little incentive to restrain MTBE use during the year. Continued demand for MTBE as an octane blendstock is assumed to be the balancing item between the 1995 oxygenate supply and demand forecasts. MTBE as an octane blendstock is expected to average about 14 thousand barrels per day in 1995. This small volume of MTBE octane blending is evidence of the potential tightness in the oxygenate markets.

On the supply side, total oxygenate supply for motor gasoline blending in 1993 was almost evenly split between MTBE and fuel ethanol (on an MTBE-equivalent-volume basis). MTBE production averaged 136 thousand barrels per day, net imports accounted for 15 thousand barrels per day, and inventory drawdowns accounted for 11 thousand barrels per day. Ethanol production averaged 152 thousand barrels per day MTBE-equivalent volume with an inventory build of 1,746 barrels per day MTBE-equivalent volume and no net imports.[30] Total oxygenate supply is projected to increase to an average of 480 thousand barrels per day in 1995, as a result of new domestic MTBE and TAME production capacity, higher MTBE imports, and inventory drawdown.

Domestic production capacity for both MTBE and ethanol has steadily increased after the early 1980's. Federal and local tax incentives for blending renewable fuel ethanol into motor gasoline and the continued growing demand for motor gasoline octane blendstocks contributed to steady growth in demand for ethanol and MTBE. The new Federal oxygenated and reformulated motor gasoline programs stimulated a dramatic increase in MTBE production capacity within the last few years (Table 5). On the other hand, ethanol shipping costs, gasohol nonfungibility[31] with motor gasoline, and limited State tax incentives helped to restrain growth in ethanol production capacity.

EIA data suggest that limited feedstock supply, plant downtime for routine maintenance, and variable market conditions will constrain domestic production capacity utilization. Consequently, domestic production of oxygenates (MTBE, TAME, ETBE, and ethanol) is expected to

[28]Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA–0109(94/01) (Washington, DC, January 1994), p. 148.

[29]States with reformulated and/or oxygenated motor gasoline markets that reported gasohol sales include California, Colorado, Connecticut, Illinois, Indiana, Kentucky, Minnesota, Montana, Nevada, Oregon, Texas, Utah, Virginia, Washington, and Wisconsin. State gasohol sales are taken from Federal Highway Administration, *Highway Statistics 1992*, FHWA–PL–93–023 (Washington, DC, 1993), p. 11.

[30]Energy Information Administration, *Petroleum Supply Monthly*, DOE/EIA–0109(94/01) (Washington, DC, January 1994), pp. 148–149. MTBE imports from Energy Information Limited, "US MTBE Imports Remain Strong While Stocks Rebuild With End of Oxy Season," *Oil Market Listener* (San Francisco, CA, April 6, 1994).

[31]Pipelines, tank trucks, and barges used to ship motor gasoline usually also contain small amounts of water from condensation and other sources. Gasohol and other alcohol fuels absorb water and thus can be rendered unfit for use if they are transported in the same vehicles or pipelines as motor gasoline.

Table 5. Oxygenate Production Capacity, 1991–1996, and Production Forecast, 1995–1996
(Barrels per Calendar Day)

	MTBE	TAME	ETBE	Ethanol
Capacity History:				
January 1, 1991	122,500	547	0	82,643
January 1, 1992	135,090	3,689	0	93,498
January 1, 1993	182,153	5,000	815	87,053
January 1, 1994	226,703	14,500	815	90,672
Capacity Projections:				
January 1, 1995	269,553	20,640	815	103,718
January 1, 1996	282,053	24,700	815	106,718
Average 1995 Capacity	275,803	22,670	815	105,218
Capacity Utilization Factor	0.83	0.70	0.70	0.85
Projected 1995 Production	228,916	15,870	570	89,435
Volume Correction Factor for MTBE-Equivalent Volume	1.00	0.89	0.88	2.03
Projected 1995 Production MTBE-Equivalent Volume	228,916	14,123	502	181,554

Sources: Energy Information Administration, *Petroleum Supply Annual 1993*, Volume 1, DOE/EIA–0340(93)/1 (Washington, DC, June 1994). B. Haigwood and J. Stepan "Oxygenated Fuels Industry Gears Up For Reformulated Gasoline," *Fuel Reformulation* (Denver, CO, March/April 1994), pp. 48–56. National Petroleum Council, *U.S. Petroleum Refining*, Volume I (Washington, DC, August 1993), p. 147. Ethanol plant utilization factor adjusted for observed 1993 operations.

average about 425 thousand barrels per day MTBE-equivalent volume in 1995 (Table 5).

MTBE imports will also be a significant source of oxygenates and will make up some of the projected difference between total demand and domestic production. Ethanol and ETBE imports are not expected to significantly contribute to oxygenate supply because of the steep tariffs on those products (Table 6). MTBE net imports averaged 15 thousand barrels per day in 1993, primarily from very large MTBE plants (over 10 thousand barrels per day capacity) in Canada, Saudi Arabia, and Venezuela. Foreign MTBE daily plant capacity grew by 26.9 thousand barrels in 1993 and is expected to grow by an additional 60 thousand barrels in 1994 and 39.5 thousand barrels in 1995.[32] EIA assumes that MTBE net imports in 1995 will increase to 45 thousand barrels per day.

The reformulated motor gasoline program will alter the role of inventories in meeting oxygenate supply needs. The CAAA90 oxygenated motor gasoline program, which began in November 1992, introduced a highly seasonal (winter-only) demand for oxygenates. The reformulated motor gasoline program will reduce inventories' roles in meeting the winter peak demand that was observed during the first two oxygenated motor gasoline seasons. MTBE inventory draw contributed an average of 11,134 barrels per day to oxygenate supply in 1993. MTBE inventories are expected to build during the second half of 1994 to satisfy reformulated and oxygenated motor gasoline demand for oxygenates during 1995. Although the potential for 1995 oxygenate supply from inventory is highly uncertain, an average 10 thousand barrels per day is assumed for a total inventory drawdown of 3.65 million barrels.

The EPA's Renewable Oxygenate Standard mandates the use of renewable motor gasoline oxygenates in 15 percent of the reformulated gasoline pool during 1995. The Renewable Oxygenate Standard will provide an additional incentive to shift ethanol out of the Midwest gasohol markets to replace MTBE, either directly in reformulated motor gasoline blends or indirectly through conversion of MTBE production facilities to ETBE production. An average of about 24 thousand barrels per day of ethanol will be required in 1995 to meet a minimum 15 percent reformulated motor gasoline oxygenate market share under the Renewable Oxygenate Standard.

[32] B. Haigwood and J. Stepan, "Oxygenated Fuels Industry Gears Up For Reformulated Gasoline," *Fuel Reformulation* (Denver, CO, March/April 1994), pp. 53–55.

Reformulated Motor Gasoline Costs

The new requirements for oxygenates and reductions in RVP, benzene, and aromatics content in reformulated motor gasoline will lead to production cost increases that may be passed through as price premiums above the price of conventional motor gasoline.

Most published estimates of reformulated motor gasoline production costs are derived from linear programming (LP) models. EPA projects the cost of Phase I reformulated motor gasoline to average about 4.0 cents per gallon higher than the cost of conventional motor gasoline. This price premium includes fuel economy effects resulting from the change in reformulated motor gasoline's heat content due to the addition of oxygenates and the reduction in RVP. EPA estimates the average refinery cost for producing reformulated motor gasoline (excluding the average cost of fuel economy losses of 1.4 cents per gallon) to be 2.6 cents per gallon.[33]

The National Petroleum Council (NPC) estimates that the added refining cost to produce Phase I summer reformulated motor gasoline will be 5.5 to 6.0 cents per gallon. This estimate does not include fuel economy effects.[34] In its base case, NPC assumes that reformulated motor gasoline would be supplied only to the nine mandated cities and that there would be a 10-percent spillover (about 27 percent of total motor gasoline demand). With full opt-in (reformulated motor gasoline representing about 65 percent of total motor gasoline demand), the average refining cost would rise by only 0.5 cent per gallon.

The differences in LP model results arise not only because of different LP model structures and assumptions, but also because a price premium reported may represent either an average cost (based on the LP model "objective function value") or a marginal cost (corresponding to an LP model "shadow price"). In this forecast, EIA uses observed market- price premiums for oxygenate additions under the oxygenated motor gasoline program and summer RVP reductions in some motor gasoline markets to estimate the refiner's marginal cost for producing reformulated motor gasoline. Because the benzene and aromatics restrictions

[33] Environmental Protection Agency, *Final Regulatory Impact Analysis for Reformulated Gasoline* (Washington, DC, December 13, 1993), p. 306.

[34] National Petroleum Council, *U.S. Petroleum Refining*, Volume I (Washington, DC, August 1993), p. 235.

Table 6. Import Tariffs on Fuel Oxygenates, January 1, 1994

Product	General	NAFTA Canada	NAFTA Mexico	Generalized System of Preferences	Caribbean Basin
MTBE or TAME	5.6 percent	Free	Free	Free	Free
ETBE	$0.227/gal	Free	$0.201/gal	Free	Free
Fuel Ethanol	$0.540/gal	$0.238/gal	$0.484/gal	$0.540/gal	Free

Notes: • Generalized System of Preferences includes countries such as Argentina, Bahrain, Malaysia, and Venezuela. • The Caribbean Basin (Economic Recovery Act) includes Trinidad.

Source: United States International Trade Commission, *Supplement 1 to Harmonized Tariff Schedules of the United States (1994)*, USITC Publication 2690 (Washington, DC, December 15, 1993). MTBE or TAME product code 2909.19.10; fuel ethanol product code 9901.00.50; ETBE product code 9901.00.52.