COLORADO'S OXYGENATED FUELS PROGRAM: ECONOMIC EVALUATION OF THE FIRST YEAR

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Work performed under contract #68-01-7489 and work assignment #88-27.

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EXECUTIVE SUMMARY

I. BACKGROUND AND OBJECTIVES OF THE ANALYSIS

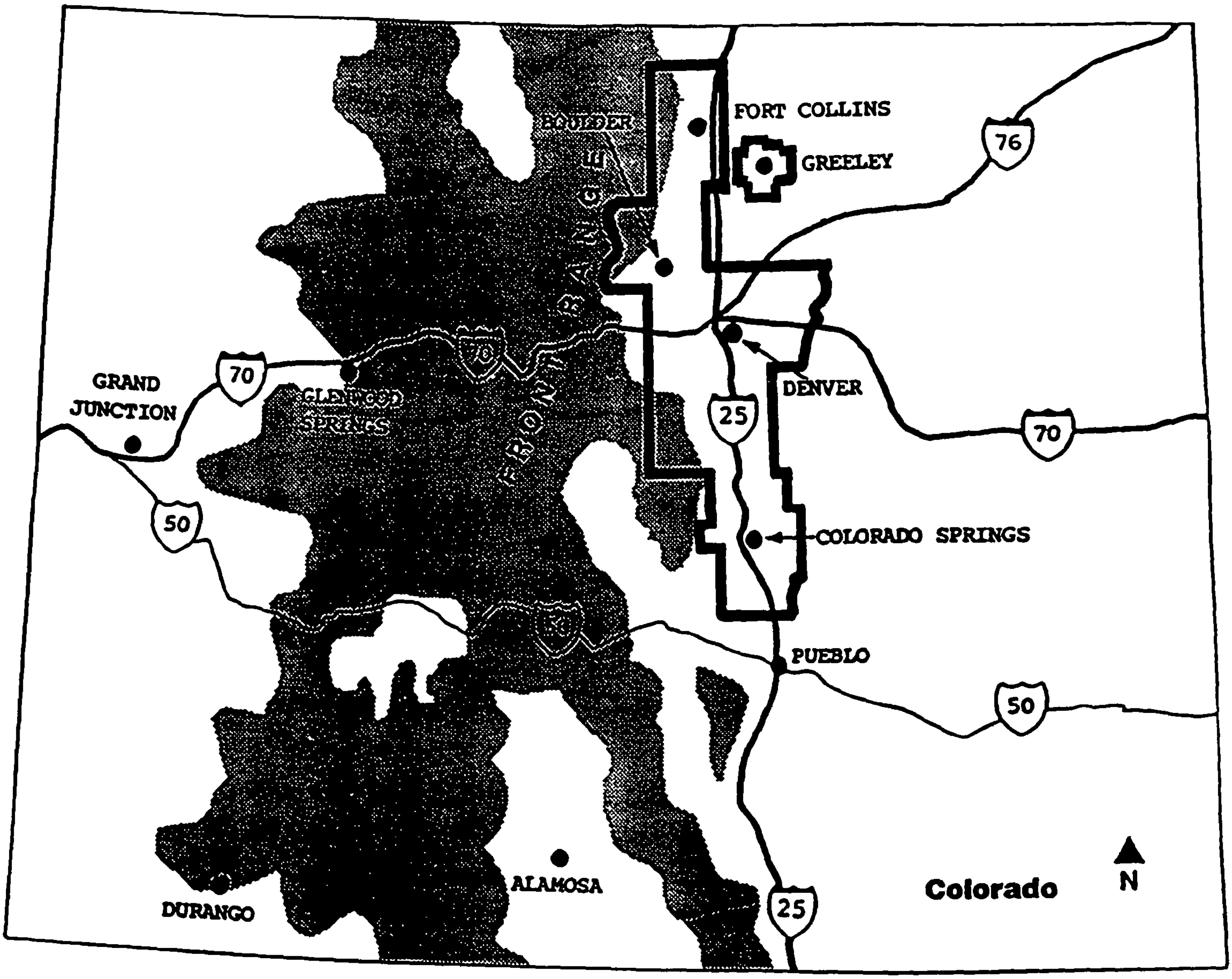
The Colorado oxygenated fuels program, Regulation 13, was enacted to reduce carbon monoxide emissions from motor vehicles in the non-attainment areas of the Front Range of Colorado (see Figure E-1). Regulation 13 requires that all gasoline sold in carbon monoxide non-attainment areas during the high pollution months of November through February contain a specified minimum 2 percent oxygen content by weight. The minimum oxygen requirement can be met by blending 10 percent ethanol (3.5% oxygen), 11% MTBE (2.0% oxygen) or other oxygenates that have obtained an Environmental Protection Agency waiver. In the first year of the program, the oxygen content standard was reduced to 1.5 percent and the mandatory blending period shortened to January and February, 1988 to allow the petroleum and oxygenate marketing industries sufficient time to meet program requirements.

The blending of oxygenated fuels in all gasoline during the high pollution months has been projected to reduce ambient carbon monoxide levels by 8 to 14 percent. The lower oxygen content of air at high altitude (18 % lower than sea level) causes most motor vehicles to burn fuel inefficiently and create excessive carbon monoxide emissions. Blending oxygenates with gasoline compensates for the lack of oxygen in the high altitude areas and reduces motor vehicle tailpipe emission.

Throughout the analysis and Rulemaking process that led to the development of the program, numerous concerns about the consequences of the program were raised. These included: the costs that would be borne by consumers and industry; potential motor vehicle driveability and maintenance problems, which could result in a lack of public acceptance; the market shares oxygenates would control at different oxygen requirements; potential decreases in

Figure E-1

Map of Colorado Regulation 13 Program Area



Air Program area within heavy box.

gasoline fuel economy; the cost effectiveness of the program as a strategy to reduce carbon monoxide exceedances and others.

The Colorado Department of Health and the trade association of the petroleum industry had economic analyses conducted prior to the program. These studies provided a large range of cost per gallon estimates of $.005 to $.08. The range in cost estimates are based on assumptions of the market penetration of a particular oxygenate, and whether other states in the region would adopt similar programs and constrain the availability of oxygenates. In addition to being computed in advance of the program, these estimates are based upon projected engineering costs that do not reflect market behavior.

This analysis was undertaken to track the program before and during implementation with the focus upon the costs of meeting the requirements. Specifically this work:

- o Tracked rack and retail prices,
- o Tracked and compared average retail and rack prices in Denver and other cities,
- o Reexamined actual incremental engineering costs for production and distribution,
- o Examines octane benefit derived from blending with oxygenated fuels,
- o Tracked and addressed market penetration by type,
- o Examines the cost per gallon and cost per ton of the program, and
- o Provides related information on other selected aspects of the program.

The first four elements provide alternative methods to examine the cost per gallon incurred by citizens and the cost to industry of the program.

II. RESULTS OF THE ANALYSIS

Market Penetration

The major suppliers of gasoline into Colorado met the program oxygen requirement by blending 8 percent MTBE in approximately 95% of the gasoline sold in the program area. A special sub-octane grade of gasoline was produced to permit the blending of ethanol during the program.

In October of 1987, the ethanol blended gasoline market had decreased to 2.1 percent, down from 20 percent in 1986, due to the elimination of a state tax credit for ethanol and other factors. During the program, ethanol had a market share of 5.3 percent. During the Regulation 13 rulemaking, members of the Air Quality Control Commission assumed that ethanol might capture an equal share of the market under a standard requiring 1.5% oxygen.

The most probable reasons for the limited market share actually experienced for ethanol includes the short term of the program in the first year; the concerns of major marketers, retailers and consumers about the suitability of ethanol; and the constrained quantity and quality of gasoline to blend with ethanol.

Production And Distribution Cost Estimates

One approach used to evaluate the incremental economic impacts of the program was to compute the incremental blending and distribution costs associated with the program.

MTBE. Strictly blending higher priced MTBE into base gasoline would increase the price of gasoline in Denver between about 2.0 and 2.4 cents per gallon. However, blending MTBE into gasoline increases the octane, and by adjusting other components that offset much of the price impacts a standard 85 octane regular gasoline can be produced. The net effect is estimated to increase production costs by between 0.4 and 0.8 cents per gallon. Adding MTBE reduces RVP, which can also further offset blending costs by the use of cheaper butanes to gain octane. The price impact of this butane substitution was not computed.

Capital costs incurred by individual producers and distributers of MTBE blended gasoline ranged from no costs (obtaining gasoline through exchanges) to building or purchasing rail off loading facilities, piping to storage, new storage tanks and in line blending equipment. These equipment purchases have productive use lives of multiple years, and, moreover, can be used for other purposes during non-program months. To account for these factors, equipment costs were annualized and apportioned entirely to the program for an upper bound estimate of 0.005 cents per gallon. For a central case estimate, these equipment costs were allocated for year round use for an estimate of 0.0005 cents per gallon.

Ethanol. The distribution of ethanol can require the replacement of filters and cleaning of storage tanks. Assuming a maximum of 20 stations switching from regular gas to ethanol for the program (based on the increase in ethanol gasoline volume), these costs were estimated to range from 0.03 cents (as a central case estimate) to 0.09 cents (as an upper bound estimate). The central case allocates the cost over one year, the upper case allocates the entire cost to the two-month program.

The estimated impact of switching to ethanol includes the change in price of ethanol related to any changes in the dominant MTBE gasoline price (estimated to be up to 1.3 cents per gallon). Ethanol users, who prior to the program purchased blended gasoline with an 87.5 octane, purchased ethanol blends during the program with 85 octane because only subgrade gasoline was available for blending with ethanol. The value of the octane impact was computed to be between 2 and 3.7 cents per gallon for those individuals who used ethanol prior to and during the program. New ethanol users were estimated to have a 1 to 2 cent cost reduction per gallon.

As an alternative method of determining whether the program significantly impacted lower gasoline prices, relative rack prices in Denver and other cities were compared. The rack price data can be interpreted to show either that Denver's prices declined relative to select cities or that conversly, there was a cost impact. However, the intrinsic, relative short-term fluctuations in rack prices across regional cities undermines the statistical validity of this approach for detecting small short-term price impacts from any one cause, and it cannot be defensably used to independently calculate program costs at the rack level.

A retail price survey was also conducted in Denver and historic Denver retail prices were compared to other cities. As with rack prices, no definite conclusions about the program price impacts can be drawn from this analysis.

Fuel Economy Impacts

Reductions or increases in gasoline consumption occur with oxygenated fuels, depending on the type of pollution controls on a motor vehicle. Using Colorado Department of Health assumptions on fuel economy penalties by oxygenate, pollution control type and existing vehicle fleet mix resulted in calculated average fuel mileage penalties of up to 0.22 percent, or a $0.002 per gallon reduction in value.

Clear Gas

Some motorists in non-program areas used clear gasoline that had been trucked in from out-of-state. Clear gasoline was generally sold at a price equal to or exceeding MTBE blended gasoline. Assuming 4.4 million gallons of clear gas sold per month at a price penalty of up to $0.013 per gallon (maximum MTBE price increment) this cost increment during the program would have been $112,463.

Other Impacts

Administrative and planning costs by industry and government did occur, but were not quantified. Similarly, the ethanol industry is reported to have experienced loss of market share attributable to a shortage of sub-octane gasoline, but the costs are not identifiable with any certainty.

Total Cost Of The Program

The range of costs identified are summarized in Table E-1. Total costs statewide ranged from $1,013,481 (central bound estimate) to no more than $3,559,604 (upper bound estimate). The lower bound estimates are zero. The costs were largely incurred by Colorado residents in the AIR area (72%), although residents in non-program areas may have incurred costs due to the Colorado petroleum distribution structure resulting in most of the state converting to oxygenated fuel. These costs are included in both the central and upper bound estimates. The central average price increase per gallon attributable to the program is $0.0045.

Cost Per Ton of Pollutant Removal

The Colorado Department of Health has estimated that a 94% market share of 8% MTBE and 6% market share ethanol (10%) reduced ambient Carbon monoxide levels in the Denver Metropolitan area from 8% to 11%, or from 160 to 220 tons per day. Using state-wide central and upper case cost estimates, and applying the carbon monoxide reductions to five days a week, the dollar per ton cost of the program would be $154.49/ton (Central estimate) to $542.62/ton (upper-bound estimate) for an 8% reduction and $112.36/ton to $394.63/ton for an 11% reduction.

Table E-1

Summary of Colorado's Oxygenated Fuels Program Costs

($ 1988)

Cost	Dollars	
	Central	Upper
MTBE		
Capital Equipment	$ 110,044	$1,031,546
MTBE Purchase	4,198,100	5,037,720
Octane Value Added	-3,358,480	-3,358,480
Total MTBE Cost	949,664	2,710,786
Ethanol		
Cleaning Costs	1,017	29,260
Market and Octane Costs	62,800	282,575
Total Ethanol Costs	63,817	311,835
Clear Gasoline	0	112,463
Fuel Economy Penalty	0	424,520
Total All Gasoline	$1,013,481	$3,559,604

Cost Impacts By Location

Cost		Dollars	
		Central	Upper
AIR AREA	- Total $	$763,837	$2,615,536
	- $/Gallon	$0.0046	$0.0159
	- $/Household	$0.868	$2.97
REST OF STATE	- Total $	$249,644	$943,968
	- $/Gallon	$0.0039	$0.0148
	- $/Household	$0.729	$2.75

* Total costs statewide. Sales volume during the two-month program: ethanol bl-ds 9,419,000; MTBE bl-ds 209,905,000; and Clear Gasoline 8,651,000.

1.0 INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

The Denver metropolitan area has been listed by the EPA as having the worst carbon monoxide pollution in the nation. In 1986, the Denver metropolitan area exceeded the CO NAAQS thirty-six times, and the single highest exceedance of the standard in the nation was recorded in downtown Denver (Metropolitan Air Quality Council, 1987).

To meet the Federal health standard, carbon monoxide emissions in the Denver metropolitan area will have to be reduced by 50 percent. Eighty-five percent of the carbon monoxide emissions are created by motor vehicles. Therefore, strategies designed to reduce carbon monoxide must either reduce motor vehicle exhaust emissions or reduce vehicle miles travelled (Metropolitan Air Quality Council, 1987).

The Interim CO State Implementation Plan for the Denver Metropolitan Area identified oxygenated fuels as the most effective carbon monoxide reduction strategy available to the metropolitan area to help reduce ambient carbon monoxide levels to meet the Federal health standards (NAAQS) and to avoid up to $30 million annually in federal sanctions. Oxygenated fuels are gasolines blended with a component or components containing oxygen: either alcohols or ethers. These fuels are asserted to be effective in reducing motor vehicle exhaust emissions by up to 34 percent (Colorado Department of Health, 1985).

The carbon monoxide emission reductions due to oxygenated fuels are dependent on the type and concentration of oxygenate used and the emission controls present on a motor vehicle. The two oxygenates that were given the most consideration in developing the Colorado oxygenated fuels regulation were ethanol and MTBE.

Analysis of the effectiveness of oxygenated fuels by the Colorado Department of Health estimated that a mandated program could reduce ambient carbon monoxide levels by 8-16 percent (Oxygenated Fuels Task Force, 1986).

EPA and local air quality officials throughout the country are also examining the use of oxygenated fuels to reduce carbon monoxide in other non-attainment areas. In Arizona, oxygenated fuels may soon be mandated either by EPA in response to a court order or through bills pending in the Arizona Legislature. In Washington, D.C., several proposed revisions to the Clean Air Act require the use of oxygenated fuels in carbon monoxide non-attainment areas. Other proposed Federal legislation would require the blending of ethanol (an oxygenate) in a large portion of gasoline sold in the United States for both energy and air quality reasons.

1.2 OBJECTIVES OF THIS REPORT

The objectives of this analysis are to provide improved estimates of the costs of the Colorado oxygenated fuels program based upon the actual experience. Prior to the oxygenated fuels rulemaking, economic analyses of the proposed Colorado program were conducted for the Colorado Department of Health (BBC, 1987) and for the trade association of the petroleum industry (EAI, 1987). Both analyses took similar approaches: they projected expected engineering costs of complying with different oxygen content requirements and estimated per gallon cost increases attributable to different market share scenarios.

Interestingly, the results of those two studies differed dramatically. The State estimates varied from $.005 to $.035 per gallon while the industry estimates ranged from $.042 to $.08 per gallon.

The results of both prior studies are subject to question as substantial acknowledged uncertainty existed in many of the estimates. Engineering cost estimates also often ignore mitigating behavior on the part of producers and consumers, which may result in overstated cost estimates. Subsequent to the completion of the program, EAI (1988) and Amoco Oil have produced revised estimates of the program costs (Denver Post, March 29, 1988) based upon comparisons of changes in the wholesale price of gasoline in Denver and other cities, from which a $.022 to $.047 per gallon price impact is estimated, plus they added an assumed fuel economy decreases of three percent per vehicle to yield an estimated total cost of $14 million in the first year of the program.

Because the Colorado program is the only mandated oxygenated fuels program in the nation, the Environmental Protection Agency, Office of Policy and Planning Evaluation, contracted for this analysis of the economic impact of the Colorado program. This analysis was conducted prior to and during the actual implementation of the program (January and February, 1988) to obtain the most accurate and timely information on actual program costs. This analysis considers:

- Engineering and production costs considering actual facility and cleaning costs as well as component substitution in the production of oxygenated gasoline,
- Changes, and valuation, of octane in gasoline,
- Market penetration of the oxygenates in the Front Range and Statewide,
- The ability to reveal market price impacts using comparisons of rack and retail prices, and
- The cost of fuel economy losses based upon the Colorado Department of Health assumptions.

This analysis also briefly touches upon the issues and evidence concerning the other social costs of the program.

The remainder of the report is divided into four sections:

- Chapter 2 introduces the Colorado program: what oxygenates are and selected issues of concern in implementing an oxygenated fuels program.
- Chapter 3 reviews the Colorado petroleum industry, and market shares and prices for ethanol, MTBE prior to and during the program.
- Chapter 4 estimates the economic costs of the program through review of engineering costs, market prices and other social impacts including reduced fuel economy.
- Chapter 5 summarizes the results and relates them to estimated tons of carbon monoxide reduction.

2.0 BACKGROUND ON THE COLORADO PROGRAM AND OXYGENATED FUELS

2.1 THE COLORADO PROGRAM

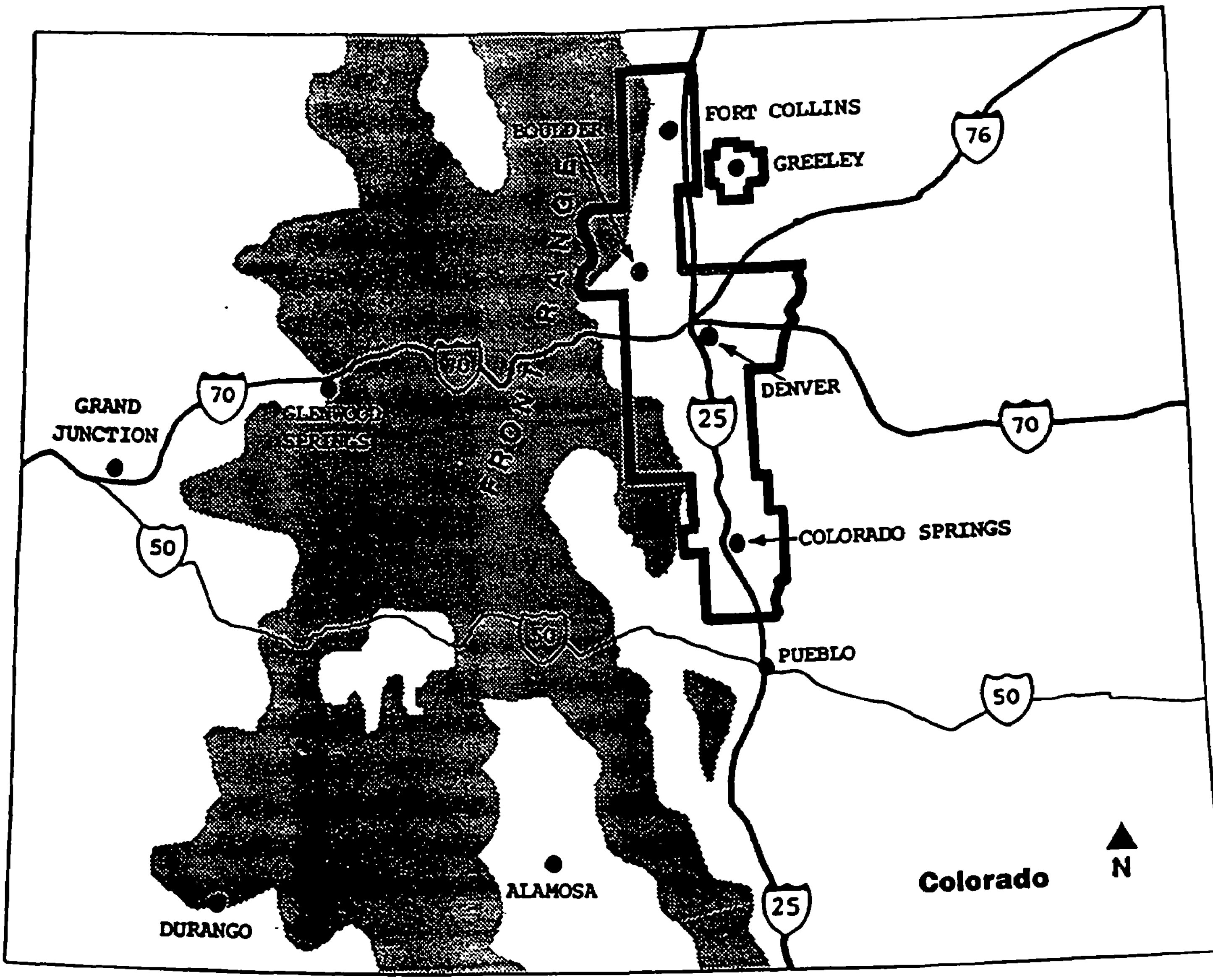
Colorado's oxygenated fuels program (Regulation 13, Appendix B) was established in June, 1987 (Code of Colorado Regulations, 5 CCR 1001-16, 1987). In the first year of the program the implementation period was January 1 through March 1,1988. The first year of the program established a shorter program duration (two months) and lower oxygen standard (1.5 percent) than the requirements of the second and subsequent years to allow the petroleum industry time to adjust to the production and distribution of oxygenated fuels. In the subsequent years of the program, Regulation 13 requires all gasoline to contain a minimum of two percent oxygen content (by weight) as the optimal oxygen level that will achieve maximum CO reduction and encourage healthy competition between ethanol and MTBE. Program implementation in subsequent years will be November 1 through March 1, which is during the high pollution season.

Pursuant to Regulation 13, the Air Pollution Control Division established a mechanism for spot testing the oxygen content of gasoline at retail stations. The Division employed five personnel to obtain fuel samples, and one staff member to maintain records. The Division conducted 556 inspections and issued 45 Notice Of Violations to retail service stations found to have failed to meet minimum oxygen content requirements (Colorado Department of Health, 1988).

Oxygenated fuels are mandated only in the areas of Colorado where the CO NAAQS are violated in the Front Range of Colorado (Figure 2-1). However, because of the gasoline distribution system in Colorado, substantial portions of the State appear to also have been impacted by Regulation 13 during the first year of the program.

Figure 2-1

Map of Colorado Regulation 13 Program Area



Air Program area within heavy box.

In addition to regulating the distribution and oxygen content of gasoline, the oxygenated fuels program was designed with the intent of minimizing potential driveability problems that could be caused by the use of oxygenates (see Section 2.3). Regulation 13 was predicated on state law that requires all gasoline meet fuel volatility standards (ASTM D-439) to minimize driveability problems. State law exempts gasoline blended with ethanol from meeting ASTM D-439; however the base gasoline must meet ASTM specifications (see Section 2.3).

In accordance with State law, the Oil and Gas Inspector of the Division of Labor is required to test and ensure that all gasoline sold in Colorado meets appropriate ASTM and octane requirements. The Oil and Gas Inspector checks fuel sold at refineries and terminals and conducts spot checks of retail service stations. If gasoline does not meet the appropriate ASTM or octane requirements, the Inspector can require that the fuel be removed from the market.

2.2 WHAT ARE OXYGENATED FUELS?[1]

Oxygenated fuels were first used in response to the oil embargoes of the 1970s. In an effort to reduce demand for imported oil, ethanol usage was encouraged through federal tax incentives to substitute ethanol for gasoline.

Oxygenated fuels also came into demand as octane enhancers in the early 1980s. The demand for all oxygenates as octane enhancers accelerated when the Environmental Protection Agency required that the levels of lead in gasoline be reduced. Prior to the EPA's lead phasedown policy, lead was utilized extensively as an octane booster in gasoline (1988).

Studies conducted by the EPA and papers presented by the Society of Automotive Engineers initiated the examination of using oxygenated fuels as a pollution

[1]References to exhibits refer to documents produced for the Colorado Air Quality Control Commission Rulemaking hearings, June 18 and 19, 1987.

reduction strategy. The State of Colorado began investigating the possibility of utilizing oxygenated fuels as a carbon monoxide reduction strategy in 1978, and conducted a series of studies that demonstrated use of oxygenated fuels appears to significantly reduce carbon monoxide emissions (Colorado Department of Health, 1987).

The Clean Air Act (42 USC 7401 et sec.) established limitations on products that can be blended with unleaded gasoline. The restrictions established in Section 211 of the Act reduces the pool of available oxygenates to those that have obtained EPA approval. Currently, there are 8 oxygenates that possess EPA approval: ethanol, MTBE, the DuPont Waiver, Oxinol, Octamix, TAME, DIPE and TBA.

The composition of the available oxygenates all differ significantly. However, the oxygenates can be divided into two general categories:

- o Alcohols: (ethanol and methanol) These include ethanol, TBA and the methanol based oxygenates (trade names; the DuPont waiver, Oxinol and Octamix)

- o Ethers: These include MTBE, TAME and DIPE (Renewable Fuels Foundation, Technician's Manual, 1987).

Ethers are derived from blending various petroleum feedstocks. Currently, the EPA waiver permits the blending of a maximum of 11% MTBE by volume with gasoline. 11% MTBE is the equivalent of 2% oxygen content by weight. TAME and DIPE are permitted up to a 2% oxygen content (Renewable Fuels Foundation, 1987).

Ethanol is produced through the fermentation of agricultural products (corn, wheat, milo etc.) to produce a fuel grade alcohol. The EPA waiver allows the blending of up to 10% ethanol (90% gasoline, 10% ethanol), which produces an oxygen content of 3.5%. Ethanol is almost always sold at 10% by volume to take advantage of Federal tax credits (Renewable Fuels Association, 1987).

Methanol can be produced from almost any carbon source, such as crude oil, coal, biomass, etc. Currently, the least expensive method of producing methanol is utilizing natural gas as a feedstock. Methanol is always blended with other alcohols (cosolvents). The Oxinol waiver permits the blending of 9.6% oxinol with gasoline and produces an oxygen content of 3.5%. The Dupont Waiver permits a maximum 3.7% oxygen from blending up to 5% methanol plus a minimum 2.5% cosolvent alcohol.

2.3 SELECTED ISSUES IN IMPLEMENTING AN OXYGENATED FUELS PROGRAM

Throughout the development of Regulation 13 certain key concerns were raised as possible impediments to the implementation of the oxygenated fuels program. This section briefly describes concerns and costs of the oxygenated fuels program in Colorado. These include issues that affect both oxygenates and gasoline such as volatility control, and concerns that are more pronounced with oxygenated fuels than gasoline, such as the solvent nature of alcohols, phase separation and materials compatibility.

Volatility

Gasoline is blended to achieve certain quality control specifications. One important fuel quality specification is the ability of a fuel to vaporize (change from a liquid to a vapor). The rate of vaporization (referred to as volatility) will determine how well a fuel will perform under varying conditions. Volatility guidelines are established by the American Society of Testing and Materials (ASTM) and are generally followed by gasoline refiners and blenders. These volatility guidelines include standards for Reid Vapor Pressure (RVP), distillation profile and vapor/liquid ratio (ASTM, 1986).

Meeting ASTM volatility standards is critical to ensuring proper motor vehicle performance. The ASTM standards reflect temperature during seasons, climate and altitude. Gasoline is blended to meet conditions governed by the applicable standard in a geographic area. A fuel with a low volatility in cold weather may have trouble starting. A fuel with high volatility in hot weather may vapor lock and stall.

Blending alcohols with gasoline raises the volatility of the gasoline (Oxygenated Fuels Task Force, 1986). Colorado law requires that all finished gasoline or gasoline blends (except ethanol) meet ASTM volatility standards. State law requires that ethanol be blended with a gasoline that meets ASTM standards.

An issue throughout the development of Regulation 13 was whether the exemption of ethanol from ASTM standards would increase the likelihood of vapor lock and create driveability problems for Colorado motorists. The basis for the concern was the possibility that gasoline blended with ethanol that exceeds ASTM standards may gain significant market penetration during the non-winter warm weather months and increase the possibility of vapor lock. However, in approving the Regulation 13, the Commission concluded that increased vapor lock would not likely be a problem because other states have substantial ethanol penetration year round, and the use of oxygenated fuels was mandated only for the cold weather months of November through February.

In addition to mitigating driveability problems, RVP controls can reduce evaporative emissions (Oxygenated Fuels Task Force, 1986). Gasoline with a high RVP produces more evaporative emissions, which contribute to the formation of ozone, than a low RVP gasoline. The addition of ethanol to a gasoline with a high RVP (permitted by ASTM and Colorado Law) can increase the tendency of the gasoline to form evaporative emissions (NAP, 1987). However, ozone formation in the Denver metropolitan area is a summertime phenomena, and, in approving Regulation 13, the Commission concluded that even if ethanol achieved substantial year-round market penetration, the increased evaporative emissions attributable to ethanol would not significantly exacerbate Denver's ozone problem.

Materials Compatibility and Solvent Nature of Alcohols

Alcohol fuels have characteristics that require they be transported, stored and blended differently than gasoline. These distinctive handling requirements create expenses not normally incurred by gasoline marketers. Additionally, some fuel systems in early model motor vehicles (1980 models and earlier) had elastomers (rubber parts) that were not fully compatible with alcohols. Introduction of alcohols into a fuel system of an early model motor vehicle could cause the elastomer to swell and force the premature replacement of the elastomer.

Alcohols also have the ability to remove deposits that have built up in the inside of vehicle gasoline tanks, storage tanks or pipelines. When alcohol blends are introduced into a storage tank, the deposits can be released. The release of deposits can result in clogging of a vehicles fuel filter or result in having impurities in a fuel. Alcohols are not shipped through pipelines because of the their ability to release impurities.

The Commission heard testimony that older cars (frequently owned by less affluent motorists) were susceptible to experiencing the potential problems that alcohol fuels are alleged to create. At issue was whether mandating oxygenated fuels would result in widespread use of ethanol and the resulting possibility that owners of older cars may be required to incur expenses not associated with the use of unblended gasoline. The Commission concluded that the risk posed by ethanol was acceptable, and consumers would have the opportunity to use MTBE if they chose.

Phase Separation

Alcohols, unlike gasoline and ethers, are soluble with water. If there is water in a gasoline storage tank, and alcohol is introduced into that tank, the water and alcohol can mix and form a distinct water and alcohol layer. This is referred to as phase separation.

If phase separation does occur in a gas tank, the engine will not be able to burn the water-alcohol layer, and the vehicle will have driveability problems. There are a number of maintenance steps taken by blenders and retailers of ethanol to avoid phase separation and the release of impurities created by the solvent nature of alcohols. The maintenance practices (and costs) range from simply changing filters on pumps, to pumping storage tanks dry prior to introduction of blended fuels to cleaning and drying the tanks. The costs of these procedures are discussed in Chapter 4.1.

3.0 THE COLORADO PETROLEUM INDUSTRY

This section provides an introduction to the production and distribution of gasoline and oxygenates in Colorado, which serves to highlight those companies affected by the program. Additional background on the Colorado petroleum and oxygenate industries can be found in BBC (1987) and EAI (1986, 1987). The chapter also addresses market penetration and prices of ethanol and MTBE prior to and during the program.

3.1 GASOLINE PRODUCTION AND DISTRIBUTION

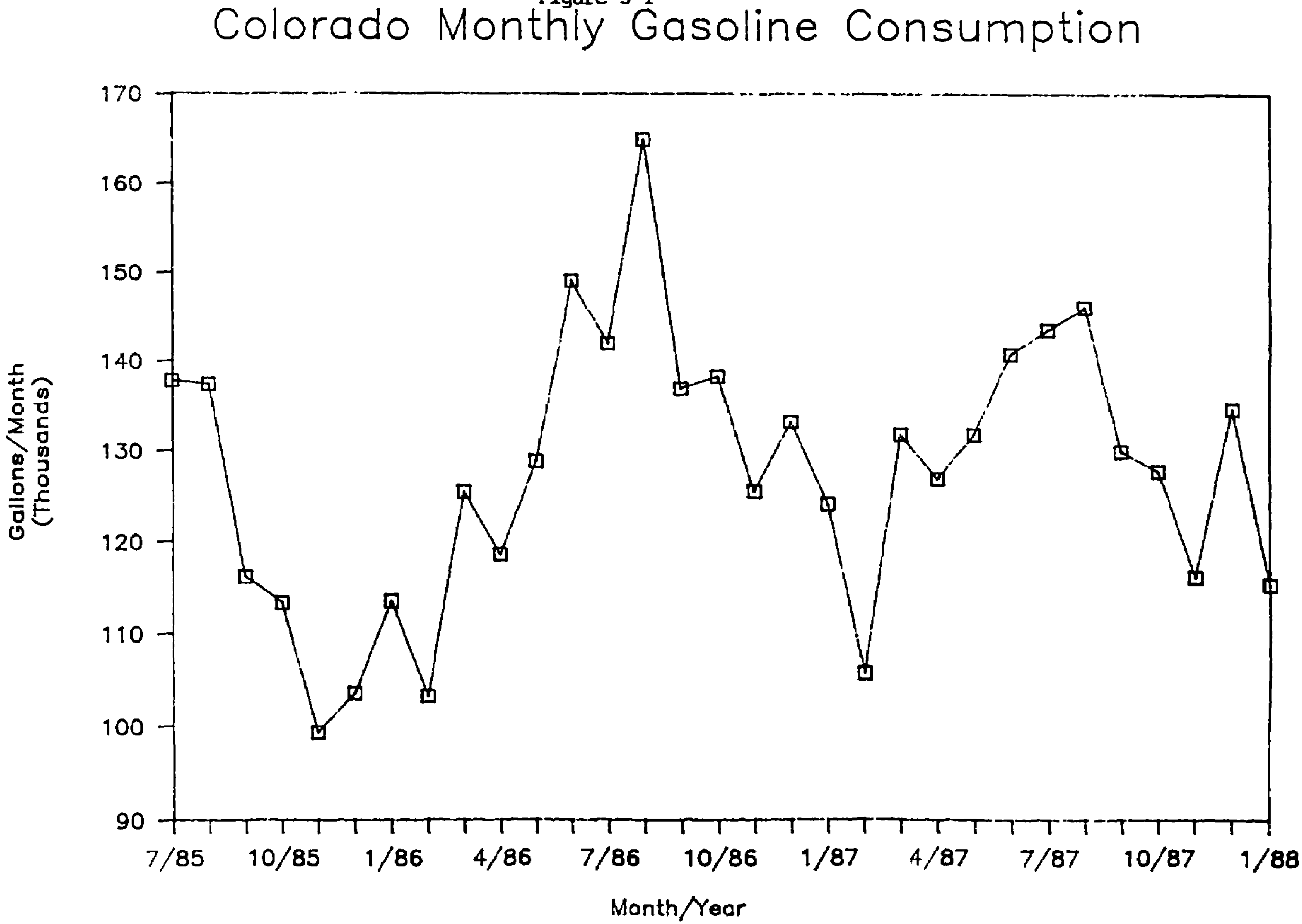
Eight petroleum companies are the primary suppliers of an average of 101,340 barrels (42 gallons per barrel) per day of gasoline into Colorado in 1986 (1987). Figure 3-1 shows the actual monthly sales of gasoline from 1986 through January 1988. In January 1988, the first month of the program, 2,750,000 barrels of gasoline were sold in Colorado. The Regulation 13 program area consumes approximately 72 percent of the gasoline sold in Colorado (BBC, 1987).

Gasoline sold in Colorado is supplied either by two local refineries or is shipped through one of the four pipelines that have access to Colorado's Front Range (see Figure 3-2). The two local refineries are Conoco and Total, each of which is located in Commerce City. These two refineries produce 33,300 barrels per day (BPD) of the gasoline sold in the State. Both refineries have approximately 15 percent of the gasoline market in Colorado.

Each of the four pipelines serves different refineries and move varying amounts of gasoline into Colorado (1986 estimates from EAI, 1987):

- o The Wyco pipeline serves the Amoco and Frontier Refineries and moves approximately 24,600 BPD into Colorado.
- o The Phillips pipeline serves Phillips Petroleum and Diamond Shamrock and moves 15,300 BPD.
- o The Chase pipeline serves Texaco and others and moves 14,400 BPD.

Figure 3-1

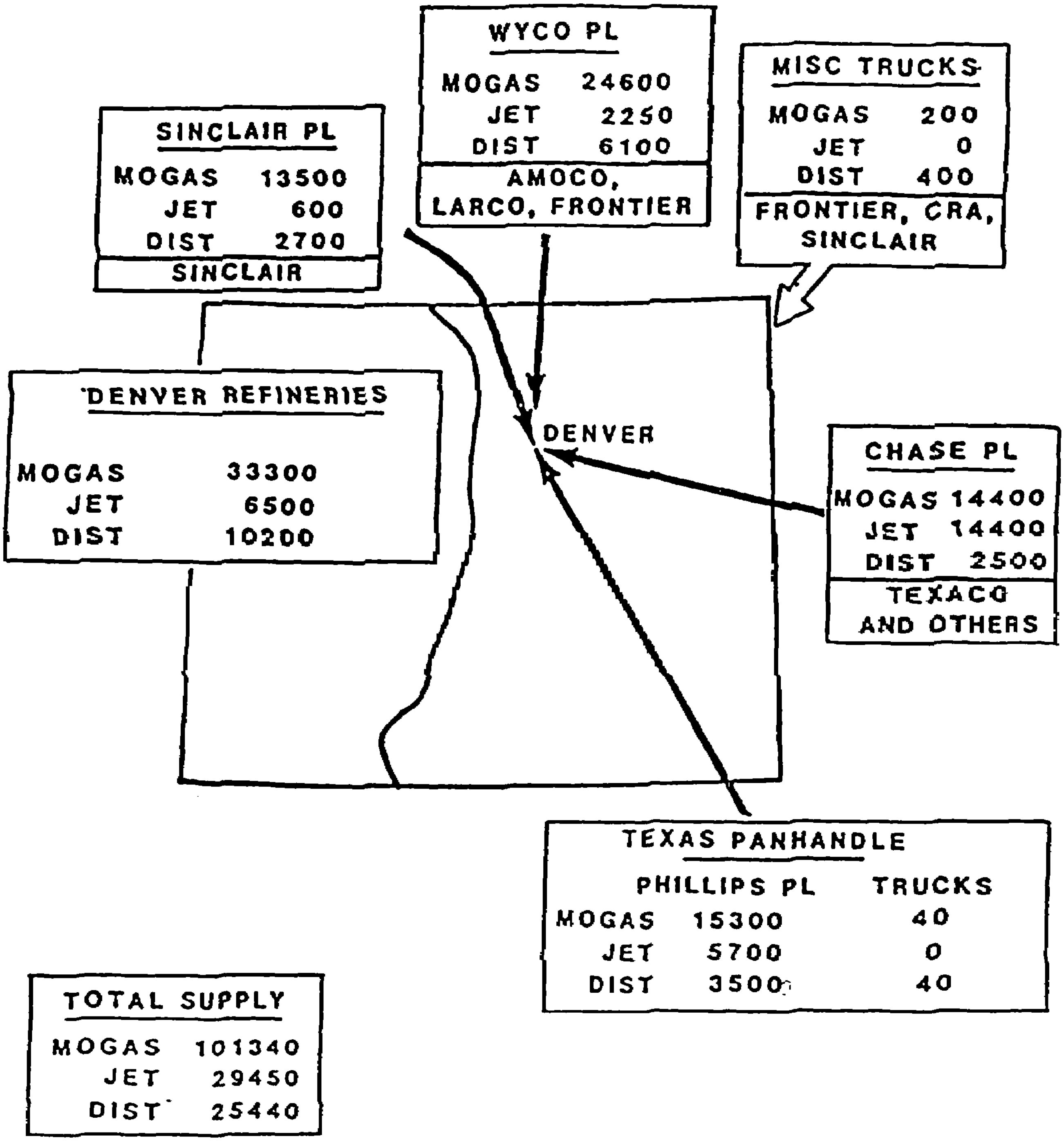


Source: Colorado Department of Revenue, 1988

Figure 3-2

FRONT RANGE COLORADO
PHYSICAL SUPPLY OF REFINED PRODUCTS

0 1986
0 UNITS: ANNUAL AVERAGE BPD
0 PRIMARY SUPPLIERS SHOWN



Source: Energy Analysts International Inc., 1987

- The Sinclair pipeline is a proprietary pipeline and moves 13,500 BPD.
- Trucks move only 600 BPD into the Front Range.

Ethanol Production and Distribution

The Coors Brewery in Golden, Colorado is the only existing source of ethanol production in Colorado. Coors can produce up to 120,000 gallons of ethanol a month from its beer waste stream and yeast production process. To ensure product quality which meets industry standards, Coors adds a detergent and corrosion inhibitor package to their ethanol. The volume of ethanol production is seasonal, with the least production occurring in December, January and February, the time frame of the mandatory program. Assuming its maximum production capacity, Coors was capable of producing 25.7 percent of the ethanol used during the program, or 1.4 percent of the total oxygenate needed to meet the requirements of a 100 percent ethanol program.

Of the approximately 65.4 thousand barrel per day ethanol production in the United States in 1986, 63 percent of the production capacity is located in the Midwest (EAI, 1987), with Archer Daniels Midland of Illinois having 50 percent of the nations' production capacity (Oxygenated Fuels Task Force, 1986).

The three primary ethanol marketers in the program area (Ethanol Managment Company, Spruce Oil and Western Refining) obtain their ethanol either from Coors Brewery in Golden, Colorado, or by rail from Archer Daniels Midland. A 100% ethanol penetration during the mandatory program would have required approximately 6,387.0 barrels per day for the program area and 8,870 barrels per day Statewide or 9.8% and 13.6% respectively of the national daily ethanol production capacity.[1]

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[1]Analysis of the volume of oxygenate necessary to meet the requiremen of the program must be based on the gasoline sold in the Front Range ar However, blended fuel was sold throughout the entire State.

MTBE Production, Pricing and Distribution

MTBE is a petroleum based chemical produced from two refinery products, isobutylene and methanol. The price of MTBE is directly related to the price of crude oil, the price and availability of feedstocks, and the price of substitute octane blend stocks such as toluene. While MTBE prices generally track with the price of crude petroleum, supply-demand imbalances of MTBE and required feedstocks result in price fluctuations. The overall demand for octane blend stocks has increased with the phasedown of lead in gasoline.

Toluene, a petroleum based product that is not an oxygenate, is another commonly used octane enhancer and a substitute for MTBE. Because of its substitutability, the price of toluene constrains the price of MTBE. In the last few years the demand for toluene as a chemical feedstock has increased its relative price giving MTBE an economic edge in enhancing gasoline octane (BBC 1987).

MTBE is used as an octane enhancer in other areas of the country because of its high octane value (blending octane of 108-112) and low volatility (RVP 8). In Colorado, small amounts of MTBE in low concentrations (2-4 percent) were blended prior to the program to boost gasoline octane. To meet the Colorado Regulation 13 oxygen requirement, MTBE was blended with gasoline in an 8 percent mixture.

U.S. production capacity for MTBE in 1987 was approximately 81.7 thousand barrels per day nationally. Approximately 91 percent of the production capacity is in Texas, with two companies, ARCO Chemical and Texas Petrochemical, possessing 68 percent of domestic MTBE production capacity (Colorado Department of Health, 1987). MTBE production was projected to increase to 100,000 BPD by the beginning of 1988 (BBC, 1987). MTBE is also imported into the U.S. MTBE can be transported into Colorado either by rail or, when it is blended in gasoline, through a pipeline.

Based on January, 1988 sales, a 100% penetration of 8 percent MTBE during the mandatory program would have required approximately 5,100 barrels per day for the program area, and 7,096 barrels per day Statewide. A 100% MTBE program would represent 6.2% and 8.7% respectively of the daily national MTBE production capacity. A 100% MTBE program (using January, 1988 gasoline volumes) using 11% MTBE would represent 8.6% and 11.9% of the 1987 daily MTBE production.

Retail Network

There are approximately 3,210 service stations in Colorado, with 1,589 located on the Front Range. Non-branded suppliers and bulk consumers account for one third of total gasoline sales in Colorado. Among branded retailers in Colorado, Amoco had 13% of the market, Conoco 12.8%, Texaco 10.3%, Phillips 6.7% and the rest is divided among numerous other branded retailers (BBC, 1987). In the program area, ethanol was sold in sixty non-branded retail stations.

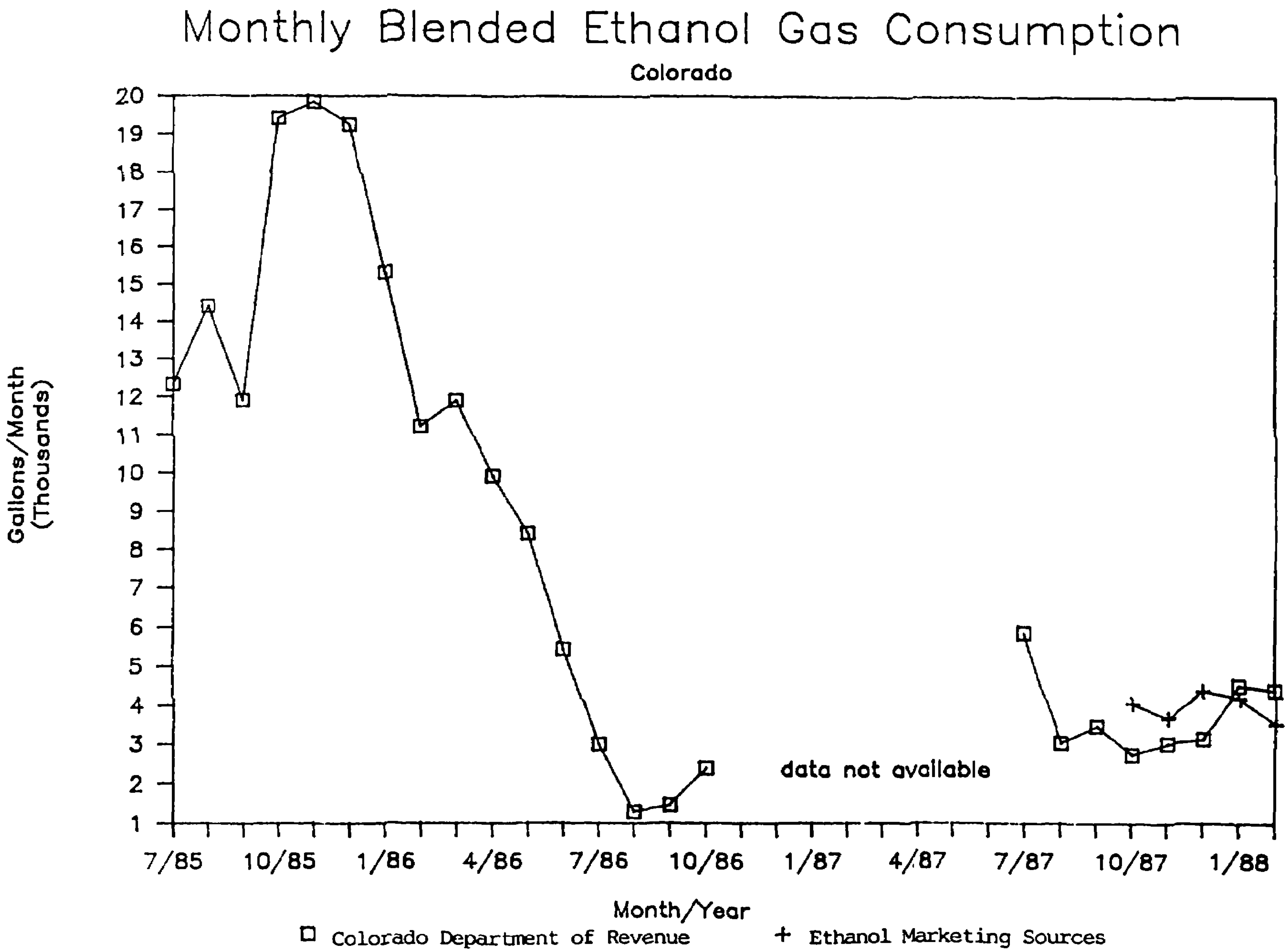
3.2 HISTORICAL MARKET SHARES AND PRICES OF ETHANOL AND MTBE BLENDS

Ethanol

Of the two oxygenates available during the mandatory program, only ethanol has a history of substantial market penetration in Colorado. Historically, the periods of greatest ethanol sales growth and decline correspond with the adoption and elimination of a Colorado five cent per gallon ethanol tax credit. The State of Colorado provided a five cent per gallon tax credit for ethanol from July of 1978 to June of 1986. Figure 3-3 shows historical Colorado Department of Revenue Statewide sales of ethanol prior to and during the mandatory program and industry estimates of ethanol sales. During the program ethanol use represented 0.6 percent of U.S. production.

Federal tax incentives lower the gross cost of ethanol so that it can be economically blended with clear gasoline. Ethanol is generally priced so that the net tax cost of the blended product will be two cents per gallon below the rack price of gasoline. The two cent difference may be used to pay for some

Figure 3-3



Monthly Blended Ethanol Gas Consumption
Colorado
Gallons/Month
(Thousands)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
data not available
7/85
10/85
1/86
4/86
7/86
10/86
1/87
4/87
7/87
10/87
1/88
Month/Year
Colorado Department of Revenue
+ Ethanol Marketing Sources

of the costs of selling ethanol, such as tank cleaning, to increase the retailers' margin or passed along to the consumer. In the Denver area retail ethanol blended gasoline prices average about a cent less than other gasoline, but varies by retailer.

Ethanol prices are site specific depending on the supplier, market, method of transport (rail or truck) and incentive programs. The delivered price of ethanol does not include the federal tax incentive.

MTBE

There is virtually no history of MTBE sales in Colorado prior to the mandatory program. Small concentrations of MTBE (blended at 3-4%) were sold in the premium gasoline of some major retailers in the State prior to the mandate. Independent marketers blended MTBE in gasoline prior to the mandate. For proprietary reasons, concentrations and volumes of MTBE sold in the State are not available.

MTBE is sold at the Gulf Coast price plus transportation. Figure 3-4 and Table 3-1 show the Gulf Coast spot market price of MTBE. Transportation costs vary by company, shipment size and other factors. On average, approximately 8 to 10 cents per gallon must be added to the Gulf Coast price for rail transportation costs to Denver (Colorado Department of Health, 1987).

Prior to the program, concern was expressed about increases in oxygenate prices resulting from the Colorado program demand (EAI, 1987). Colorado demand for MTBE and ethanol was small relative to production capacity and, according to industry sources (ARCO Chemical, the primary supplier of MTBE), did not have an impact on oxygenate prices. Statewide Colorado use of MTBE in January was 8.0 percent of daily U.S. production.

Figure 3-4

Ethanol, MTBE and Crude Prices

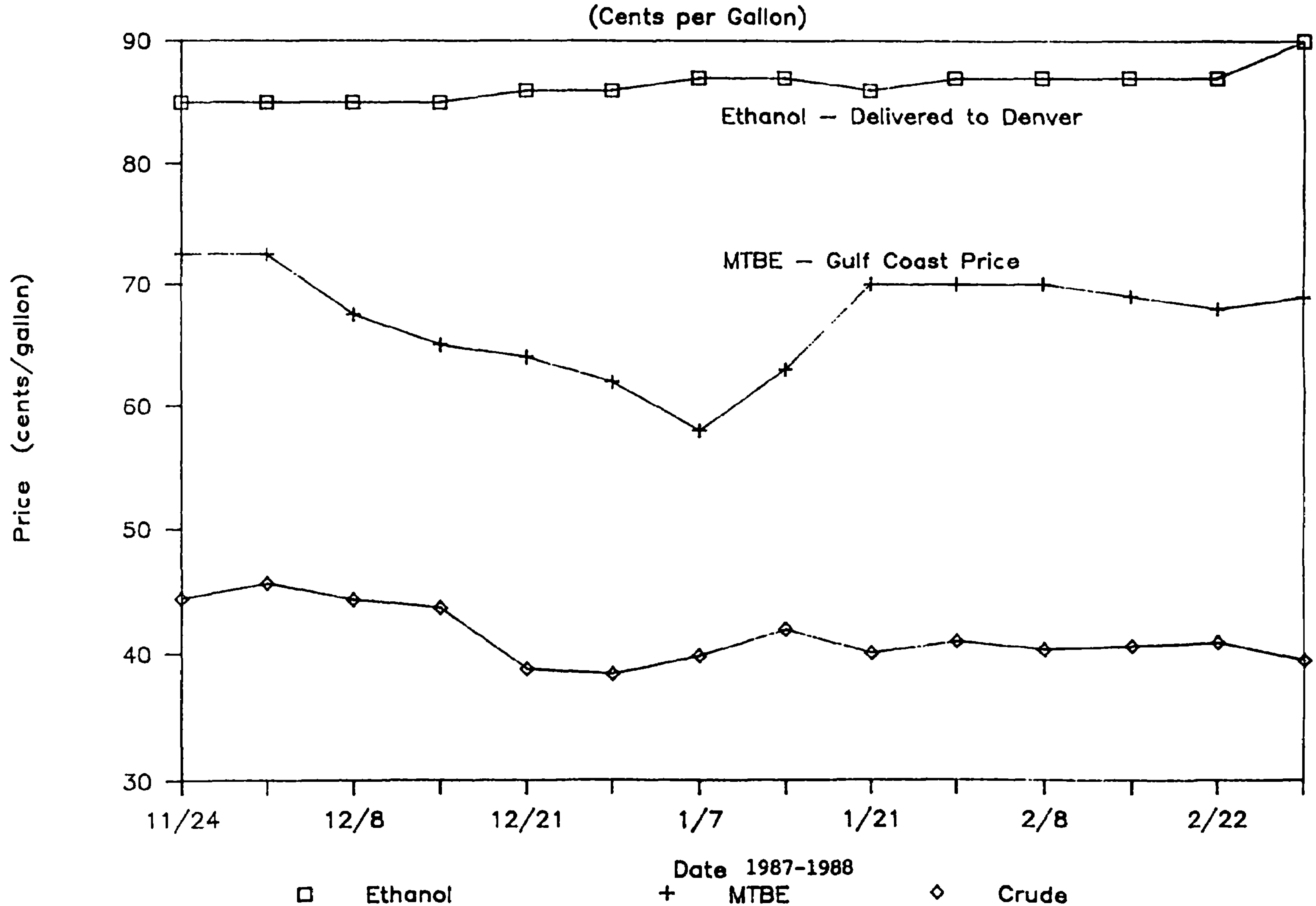


Table 3-1

MTBE and Ethanol Prices

(Cents Per Gallon)

Date	**Ethanol**[1]	**MTBE**[2]
November 24	85.00	72.50
November 30	85.00	72.50
December 8	85.00	67.50
December 15	85.00	65.00
December 22	86.00	64.00
January 4	86.00	62.00
January 11	87.00	58.00
January 18	87.00	63.00
January 25	86.00	70.00
February 1	87.00	70.00
February 8	87.00	70.00
February 15	87.00	69.00
February 22	87.00	68.00
February 29	90.00	69.00

1 Delivered Price to Denver excluding the federal tax incentive of 10 percent or 60 cents per gallon.

2 Gulf Coast Spot Market Price. 8 to 10 cents per gallon must be added for rail delivery to Denver.

3.3 MARKET SHARE AND PRICES OF ETHANOL, MTBE AND CLEAR GASOLINE DURING THE MANDATORY PROGRAM

The volume of a particular oxygenate used during the mandatory program is dependent on the percentage of the market the oxygenate possesses and the oxygen content requirement of Regulation 13. In the first year of the program, 8 percent MTBE was used to meet the 1.5 percent oxygen standard. Ten percent ethanol (3.5% oxygen) was blended with gasoline to take advantage of federal tax credits. The sales of gasoline during the program months of January and February 1988 are summarized in Table 3-2.

In preparation for and during the mandatory program, the four pipelines shipped gasoline blended with MTBE into Colorado for most of December and all of January and February.[2] The practical result of MTBE being blended with all gasoline transported into, and refined in, the State was the virtual elimination of any gasoline suitable for blending with ethanol, as is normally done. To ensure the availability of a blending stock for ethanol, the Governor met with representatives of the refineries that service Colorado and arranged for the production of gasoline suitable for blending with ethanol. Consequently, a special non-oxygenated "sub-octane" gasoline (82.5 octane unleaded regular, 84 octane regular) was produced to allow the blending of ethanol. Three refineries, Conoco, Total and Sinclair, were the only suppliers of sub-octane gasoline. The sub-octane gasoline sold for one cent less per gallon than unleaded gas. The rack prices of MTBE and ethanol just prior to and during the program are summarized in Figure 3-4 and Table 3-1.

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[2]Several refiners and blenders began to produce and distribute oxygenated fuels by mid-December. The earlier start was necessary to ensure that retail stations would have oxygenated fuels by January 1, 1988. Regulation 13 required that the type of oxygenate blend be posted on pumps in the program area from January 1 through February 29. Gasoline with ethanol was already required to be posted. Prior to the program some stations may have carried MTBE blended gasoline without knowing it. Less than three percent of the stations reported selling MTBE blended gasoline in the December 13, 1987 RCG/Hagler, Bailly Inc. retail price survey.

Table 3-2

Gasoline Sales Summary

1988 January/February

	Program Area		Statewide Area	
	Gallons	%	Gallons	%
Ethanol	9,419,000	5.8	9,419,000	4.1
Clear Gasoline	---	--	8,651,000	3.8
MTBE (11%)	3,672,000	2.3	3,672,000	1.6
MTBE (8%)	148,488,000	91.9	206,233,000	90.5
Total Sales	161,579,000	100	227,975,000	100

Sources: Colorado Department of Revenue, Colorado Department of Health

Ethanol

Using Department of Revenue estimates, ethanol blended gasoline sales (in the Regulation 13 program area) of approximately 3,318,000 gallons in December and 4,530,500 gallons in January represent 4.1 and 5.8 percent, respectively, of the oxygenate market. This would represent an ethanol sales increased 36% from December to January. However, ethanol marketing industry sources, contrary to Colorado Department of Revenue determinations, have estimated that ethanol sales for the program period actually decreased slightly based upon their sales records. No explanation for these different estimates has been determined by either source.

An issue of interest to air quality officials is why there was not greater market penetration of ethanol during the mandatory program, and whether ethanol penetration will increase next year. There are a number of apparent explanations for the weak sales of ethanol during the program. Ethanol was carried only by independent stations because the major gasoline marketers were not prepared to make the adjustments necessary to accommodate ethanol. Ethanol, unlike gasoline or MTBE, is not fungible (it cannot be shipped via pipeline, and requires special handling) and the short period between adoption of Regulation 13 and implementation of the program would have required changes in operating procedures.

Some marketers also argue that consumers do not accept ethanol as a product and are unwilling to risk consumer rejection of the oxygenate they market. However, it is interesting to note that some of the major petroleum marketers in Colorado (Amoco, Conoco, Sinclair and Texaco) currently sell ethanol in other states.

Another proposed explanation for ethanol's small market penetration is the lack of an assured supply of gasoline suitable for blending with ethanol, which may have constrained sales. Ethanol marketers were restricted in the amount and quality of gasoline that was available for blending during the months of December, January and February. Ethanol is traditionally blended with gasoline to produce a product which has a higher octane number (two to three octane points) than gasoline. Selling a high octane product is a marketing tactic of retailers of ethanol blends.

The unavailability of clear gasoline during the program forced ethanol marketers to either use sub-octane gasoline or ship gasoline in from Wyoming or Kansas if they wanted to use clear gasoline to produce a final high octane product. At least one ethanol retailer discontinued selling ethanol blended product because of the unavailability of clear gasoline.

Additionally, the sub-octane gasoline was reportedly not always available in sufficient quantities for blending with ethanol. Any of, or a combination of all of the above reasons may explain why ethanol did not gain a larger share of the oxygenate market.

MTBE

MTBE fulfilled most of the oxygenate demand for the months of December, January and February. During the program, an estimated 210 million gallons of MTBE blended gasoline was sold in Colorado. Of the MTBE sales, approximately 3.7 million gallons contained 11% MTBE, the remainder was blended at the 8% level (Colorado Department of Health, May, 1988).

Clear Gasoline

Although most of the gasoline sold in the State is transported into the Front Range, some non-oxygenated "clear gasoline" (not sub-octane) was transported into the Western Slope and the eastern plains (geographic areas outside the mandatory program area) via truck during the program months. Product was moved into the Western Slope from Utah and New Mexico. Approximately 3,000,000 gallons of clear gasoline was sold on the Western Slope in January 1988.

On the Front Range and eastern plains approximately 1,470,000 gallons of clear gasoline, 1.7 percent of statewide gasoline sales was brought in from Wyoming and Kansas by truck. Some of the clear gasoline was used to blend with ethanol, and the rest was marketed as oxygenate free gasoline.

4.0 ECONOMIC IMPACTS OF THE OXYGENATED FUELS PROGRAM

Widely varying economic impacts of Colorado Regulation were made prior to program implementation. This study uses several methods and alternative data sources to quantify the actual industry and consumers economic impacts of the program. This section presents the analyses of:

- o Capital equipment costs incurred by refineries and distributors,
- o Oxygenate costs and values,
- o Denver and regional city rack prices,
- o Denver and regional city retail prices, and
- o Changes in fuel economy.

4.1 ENGINEERING COSTS INCURRED BY REFINERS AND DISTRIBUTORS

The estimated costs of implementing Regulation 13 were based, in part, on the infrastructure costs incurred by the producers and distributors of gasoline and oxygenates. These costs included:

- o Building or refurbishing storage facilities,
- o Constructing rail unloading facilities,
- o Piping from unloading facilities to storage tanks and
- o Purchasing in-line blending equipment to enable refineries and terminals to blend and distribute oxygenated fuels.

The suppliers of gasoline and blenders of oxygenates were contacted to determine the actual costs of implementing the program. The information provided for this study will be presented in aggregated form to ensure the confidentiality of the proprietary information. All major participants in the Colorado petroleum industry were contacted and were generally very cooperative in providing information on a confidential basis (See Appendix 1 for a list of contacts).

Costs To Refiners, Distributors and Retailers Related To MTBE

Rail Off Loading and Blending Equipment. The costs incurred by individual suppliers for the purchasing and building of rail off loading and in-line blending equipment varied from no cost (suppliers who obtained blended gasoline through exchanges) to $750,000 (for an unloading facility, piping to a storage tank and in-line blending equipment). The aggregated cost for all identified rail off-loading and blending facilities totaled $2,925,000 (Conversations with gasoline and oxygenate distributors).

Storage Tanks. The refineries and terminals that supply product into Colorado possessed different storage capacity. Some suppliers utilized available tanks, others were required to rededicate existing storage tanks, and some suppliers were required to construct new tanks (the upper bound expense for constructing a new tank was $750,000). The aggregate cost for providing tanks to store MTBE and sub-octane gasoline totalled $2,100,000 (Conversations with gasoline and oxygenate distributors).

Annualized Cost of Equipment. The above equipment installed to meet the requirements of Regulation 13 generally has a life expectancy of 10 to 30 years. Therefore, the cost of the equipment should be annualized, and not charged exclusively to the first year of the program. Further, such equipment can be used by a refinery or terminal year round for purposes other than blending oxygenates during the four months of the program. For the purpose of this analysis, we have calculated the annual cost of complying with Regulation 13 in two ways (Summarized in Table 4-1):

1. As an upper bound on costs, amortizing equipment at 10 percent with a tax life seven years (Tax Reform Act of 1986) and assuming the equipment is useful only during the program; and

2. As a central estimate, amortizing the equipment at 10 percent over 15 years and assuming the equipment can be utilized the entire year and therefore, allocating the cost of the equipment to the program in proportion to the months used for the program.

Table 4-1

Annualized Cost of MTBE Related Equipment Expenditures

Cost Of Equipment		Upper	Central
Rail, Piping Blending	$2,925,000	--	--
Storage	$2,100,000	--	--
TOTAL:	$5,025,000	$1,031,546/year	$110,044/year

Sources: Amoco Oil, Conoco, Diamond Shamrock, Exxon, Frontier Oil, Phillips Petroleum, Sinclair Oil, Spruce Oil, Texaco Oil, Total Petroleum, Western Refining.

Utilizing the upper bounds of the engineering costs attributable to the first year, and attributing the entire annual cost to only the program months (January and February) gasoline sales, the engineering cost per gallon of MTBE mixed gasoline is $0.0049. This upper bound cost would be half this amount in a four-month program. Using the central case estimates, the per gallon engineering cost for two months would be $0.0005. Of the two prior studies, BBC, (1987) projected a capital cost related to using MTBE of $0.006 per gallon and EAI (1987) estimated MTBE capital costs (in total dollars on a seasonal basis) of $4.4 million.

Meeting the 2.0 percent oxygen standard in the second year of the program could require some refineries and terminals to incur additional engineering costs. To avoid the logistical problems created by the program (see Section 4.7) the refineries and terminals that will be blending MTBE shipped by railcar will have to dedicate an additional 50,000 barrel tank for storage of MTBE. In addition to providing the additional storage capacity, the blender will have to take shipment of the MTBE in August of 1988, and not receive the benefit before November 1, 1988.

Refinery operators have estimated that the cost of providing the storage for the next years program will exceed the amount spent in the first program year. Assuming all eight refineries are required to build new MTBE storage capacity, at the upper case of $750,000 each (for a total of $6 million), the annualized central case estimate of per gallon engineering costs attributable to the 1988-1989 program would be $.0017 (assuming statewide monthly consumption of 115,500,000 gallons per month).

<u>Cleaning Of Tanks Related To Ethanol</u>

The standard procedure for the handling and distribution of ethanol is to ensure that storage tanks are clean and contain no water to minimize the possibility of phase separation and the release of deposits (because of the solvent nature of alcohols). The cost estimates conducted prior to the rulemaking established a range of service station maintenance costs of $25 to $4000.

The actual costs of preparing a service station to handle ethanol tended towards the lower end cost estimates (summarized in Table 4-2). Stations incurred costs of $20 to $49 per pump hose for changing filters and pump castings. There were approximately 60 service stations on the Front Range that distributed ethanol blended gasoline during the program. Less than 20 of the stations started blending ethanol during the program. The stations that were blending with ethanol prior to the program therefore did not incur added preparation expenses due to the rulemaking.

The stations that incurred the greatest expense are those that required that water/gasoline mixture be removed from their tanks. Water from a tank must be treated as a hazardous waste, and disposal of the liquid is the greatest cost in the cleaning process. The expense of drying a storage tank ranged from $90 to $250 per tank. Approximately 50 to 70 storage tanks were dried and cleaned with a total cost range from $4,500 (50 x $90) to $17,500 (70 X $250) (Conversations with ethanol blenders and tank cleaning firms).

Table 4-2

First Year Costs Related To Ethanol

Item	$ Per Unit	# of Stations	Total Estimates Lower Bound	Total Estimates Upper Bound
Filters	$20-49 average (per pump hose)	20 (4-12 pump hoses/Station)	$1,600	11,760
Tank Cleaning	$90-250 Tank	50-70	$4,500	17,500
TOTAL:	--	--	$6,100	$29,260

Sources: Ethanol Management Company, Kubat Equipment and Service Company, Spruce Oil, Western Refining.

Assuming that twenty service stations incurred the range of cleaning costs and sold equivalent amount of blended gasoline as all stations selling ethanol blends, the per gallon cost of cleaning the stations would have been an upper case cost of $.01 and the central case of $.002. However, assuming that the same stations continue to sell ethanol year round, the costs of preparing a station are spread out over the entire year, and the per gallon cost is reduced to $.0017 and $.0003 respectively. Of the two prior studies, one estimated that the weighted average cost of preparing a service station would be $735.00. The other study estimated that service station preparation would cost retailers $.01 per gallon.

4.2 OXYGENATE COSTS AND VALUES

This section examines the production costs and octane values of blending MTBE and ethanol into base gasolines to meet the 1.5 percent oxygen requirement of the Colorado program. The gross costs of MTBE and ethanol are higher than the cost of the base gasolines they replace. This by itself would indicate higher production costs for gasoline blended with these oxygenates. However, because they boost the octane rating, a higher octane gas, with a higher market value, may be sold or other lower price octane components may be substituted to offset some or all of their cost.

4.2.1 MTBE Blending Costs

MTBE delivered to Colorado during the program averaged between 70 and 80 cents per gallon. In relative terms, this was 20 to 30 cents per gallon above gasoline during the program, or 140 to 160 percent of the cost of base gasoline. Relative prices are important in analyzing costs because gasoline and MTBE prices change over time. The program price differential between MTBE and gasoline is in the same range as historical relative prices shown by BBC (1987). A study by Energy and Environmental Analysis, Inc. (1987), using new plant economics at current petroleum prices, projects MTBE prices to remain about 25 cents more per gallon than base gasoline, thus maintaining the same price differential.

The change in cost from adding MTBE can be calculated from the prices and amounts of base gasoline and MTBE added per gallon of blended gasoline. Multiplying the price per gallon times the percent of that component in the finished product and then summing the costs will yield the cost of the product. The cost of blended gasoline can then be compared to the cost of unblended gasoline. For example, in a gallon of blended gasoline, 92 percent is base gasoline and 8 percent is MTBE. Assuming a price of 50 cents per gallon for base gasoline the component cost is $0.46 ($0.50 X .92) per gallon. Assuming the higher program price of 80 cents per gallon of MTBE, the cost is $0.064 ($0.80 X .08) per gallon. The blended gasoline cost per gallon would therefore be $0.524 or 2.4 cents more per gallon than base gasoline if no other considerations are made. Assuming the program average price of $0.75 per gallon of MTBE, the blended gasoline cost would be $0.520 or 2.0 cents per gallon more than base gasoline (see Table 4-3). These estimates of 2.0 to 2.4 cents/gallon serve as the central and upper bound estimates of program changes in production costs.

The addition of MTBE increases the octane of the base gasoline by approximately two numbers, which has a value to producers and consumers. One

Table 4-3

MTBE Blending Costs and Octane Value

Blending Component	MTBE Blending Costs: Price Per Gallon		Percent Of Gallon		Cost Per Gallon
I. MTBE Blending Costs					
Base Gasoline	$0.50	x	0.92	=	$0.46
MTBE	$0.75 - 0.80	x	0.08	=	$0.060 - 0.064
Total			1.00		$0.520 - 0.524
Change in cost per gallon (Blended cost - $0.50)				=	$0.020 - 0.024 (added cost)
II. Octane Substitution Value					
Change in Octane times Octane Value (2 x $0.008)				=	-$0.016 (Saving)
III. Total MTBE Blending Cost and Octane Value Impact					
					$0.004 - 0.008 (added cost)

Note: Assumes 50 cents per gallon for base gasoline and actual MTBE program prices of 75 and 80 cents per gallon for central and upper cost estimates. Octane substitution value is based on oil industry figures of 0.8 cents per octane gallon. This is a conservative estimate of octane value and does not include additional octane value obtained through the increased use of butane. Actual octane value varies by refinery feedstock, equipment, and operation.

method that can be used to estimate producer octane value is to compare the difference between unleaded regular and premium gasoline. Their rack prices differ by approximately 6 cents while their octane differs by 4 points (89 vs 85). Using this method, the octane value is approximately 1.5 cents per octane number per gallon. Although this estimate is probably on the high side, because it includes wholesale profits as well as production costs, it demonstrates that octane has value.

As illustrated, increased octane gasoline available from strictly blending MTBE could have been sold at a higher price or, as actually occurred, producers could maintain the octane at normal preprogram levels (85 unleaded, 86.5 regular and 89 premium). By substituting MTBE octane for other octane components, the cost of producing gasoline is decreased by the amount of octane components substituted. This savings is the production value of octane. Octane costs vary by refinery feedstock and equipment. Refineries with higher octane costs will receive larger benefits of octane enhancers than refineries with lower octane costs. The production cost to increase octane by one number has been estimated at 0.8 cents per gallon (BBC 1987) and 1.0 cent per gallon (George Yogis, ARCO Chemical, AQCC testimony June 4, 1987).

MTBE increases the octane of blended gasoline by approximately two numbers. Using a value of 0.8 cents per octane number, the octane value of MTBE through substitution of other inputs is 1.6 cents per gallon of gasoline. The 1.6 cents per gallon offsets the purchase cost of MTBE (see Table 4-3). Therefore, the net change in production cost of blending MTBE including octane value ranges from 0.4 to 0.8 cents per gallon. Confidential industry sources have confirmed these are reasonable estimates of the production costs of blending MTBE. Octane substitution benefits estimated here may be conservative as evidenced by the economic use of MTBE in other areas of the country and by the possible continued use of MTBE after the program by three companies in the Denver market.

Another form of MTBE octane substitution is also possible that would increase the blending valve. Additional octane value, other than the direct boost of MTBE, can be derived through butane substitution. Butanes are an abundant, low cost octane enhancer, but only limited amounts can be added to most gasolines because of their high RVP (55). Because MTBE lowers the vapor pressure of gasoline (RVP of MTBE = 8, RVP of gasoline = 14) when blended, additional low cost butane can also be blended to increase octane instead of using more expensive octane components.[1] The value of the substitution is termed the butane credit. BBC (1987) estimated the butane credit at 0.2 cents per gallon for 11 percent MTBE gasoline. The amount of credit depends on the price and availability of butane and the composition of the base gasoline. Because of the complexity and variability of refinery operations, butane octane credit was not included in the estimate of MTBE octane value. The inclusion of butane credit would increase the substitution value and lower the total cost of blending MTBE.

Based on the amount of MTBE blended gasoline produced during the two-month program without acknowledging the value of octane, the oxygenate purchase cost of the program ranged between $4,198,100 and $5,037,720 or $0.020 to $0.024 per gallon of blended gasoline. This serves as an upper bound estimate on the blending cost components. When adjusted for the value of octane, the cost of blending MTBE ranged from 839,620 to $1,679,240 or from $0.008 to a central estimate of $0.004 per gallon of gasoline.

4.2.2 Ethanol Costs

Although ethanol was marketed economically before the program, some consumers incurred program induced costs as a result of the ethanol pricing strategy and base gasoline substitutions. Because of the fixed margin pricing strategy of ethanol blends, the price of ethanol follows the price of the dominant gasoline. If the price of other gasoline increases because of the cost of blending MTBE, the price of ethanol blend would also increase. Gasohol consumers would pay more even if the cost of producing ethanol blend had decreased.

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[1]The winter RVP of gasoline in Denver averages 14 and must be below 15 to meet ASTM requirements (Staff Statement to the AQCC Concerning Proposed Regulation 13, June, 1987).

Previous ethanol users who stayed with ethanol may have incurred increased prices and reduced product value because the octane of ethanol blend during the program was reduced as compared to before the program. Ethanol blend prior to the program had an octane rating two to three points higher than the same grade of non-ethanol gasoline. This was considered a consumer selling point of ethanol blends. During the program, ethanol was blended with lower octane "subgrade" gasoline. The finished blend using subgrade was the same octane as other gasoline. The program induced cost was the 2 to 3 point reduction in octane. The subgrade was provided at a slightly lower cost, from one half to one cent per gallon less than MTBE blended gasoline, and was the only gasoline available for blending with ethanol. The ethanol blend gasoline to unblended gasoline price margin before the program was approximately 1.5 to 2.0 cents per gallon. The reduction in cost of the subgrade (relative to gasoline) allowed blenders of ethanol to maintain the price margin between gasoline and ethanol blend, thus, offsetting program costs and/or increasing their profit margin. Maintaining the ethanol blend to gasoline price margin results in a cost to the consumer by the save $/gallon amount of the MTBE gasoline price increase. (The price increase is in relative terms. For example, the retail price of gasoline declined during the program, but ethanol blend may not have declined as much as it would have without the program.)

The consumer cost incurred depends on the type of gasoline that was purchased before and during the program (see Table 4-4). For example, assuming up to a $0.01 per gallon increase in the cost of gasoline because of blending MTBE, the retail prices of both MTBE and ethanol blends of gasoline would increase by up to $0.01 per gallon. Consumers that purchased ethanol blends before the program and during the program paid up to $0.01 due to the MTBE effect (line 4 - line 2 in Table 4-4). Consumers that switched from gasoline to gasohol during the program paid $0.01 less per gallon (line 4 - line 1) due to the ethanol retail pricing strategy. If the change in price of blending MTBE was zero, then the consumer change in price would be zero.

Previous ethanol consumers also experienced a reduction in octane. For the central estimate of this impact, a production cost of 0.8 cents per octane gallon (2.5 octane reduction) was used. The producer value of 1.5 cents per

Table 4-4

Ethanol Program Impacts,

Costs to New and Previous Consumers

Fuel Costs	**$ per Gallon**	**Octane**
Before Program		
1. Gasoline	0.85	85
2. Ethanol Blend	0.83	87.5
During Program		
3. MTBE Gasoline	0.85-0.86	85
4. Ethanol Blend	0.83-0.84	85
Program Induced Change in Costs		
5. Ethanol Blend to Ethanol Blend (line 4 - line 2)		-2.5
- Price Impact	0.0 to +0.01	
- Octane Value Reduction	0.02 to 0.037	
- Total Impacts	0.02 to 0.047 (added costs)	
6. Switching from gasoline to Ethanol Blend (line 4-line 1)		0
- Price Impact	-0.01 to -0.02	
- Total Impacts	-0.01 to -0.02 (added savings)	

Assumes, for the purpose of sample calculation, preprogram unleaded prices of $0.85 and $0.83 with an ethanol octane boost of 2.5 and maintaining $0.02 retailer price margin. Costs of the program are from changes in base gasoline costs, changes in MTBE gasoline prices, and loss of octane. The cost to previous consumers is the total of the cost increase in other gasoline (0.0 to 0.01) plus the loss in octane value. The cost (benefit) to new consumers is the cost reduction in ethanol blends.

octane gallon (2.5 octane reduction) was used. The producer value of 1.5 cents per octane gallon was used for the upper estimate of this impact. The value of reduced octane ranged from $0.02 to $0.037 per gallon for ethanol blends as compared to the previous use of ethanol. Assuming an upper bound cost increase of MTBE OF $0.013 per gallon (calculated figure from equipment and blending costs), the total program cost for previous ethanol blend consumers ranged from $0.02 to $0.05 per gallon. The total program cost (benefit) to new ethanol blend consumers ranged from $-0.01 to $-0.02 per gallon.

4.3 DENVER AND REGIONAL CITY RACK PRICES

Gasoline rack (wholesale) price behavior in Denver was analyzed for impacts of the oxygenated fuels program. Rack prices reflect crude oil purchase costs, refining and blending costs, cost of the oxygenate, and wholesale marketing and distribution costs and profits. During the program period, Denver rack prices include the cost of MTBE, except for sub-octane gasoline. Based on the actual engineering and other costs incurred we would expect only a negligible or small change in rack prices attributable to the program (approximately zero to 0.013 cents per gallon).

Estimates of price increases from $0.034 to $0.06 were made prior to the program by BBC and EAI). This section analyzes the actual price behavior of Denver and other cities to see if these price changes can be verified.

4.3.1 Denver Rack Prices

To distinguish program related price changes, adjusted for crude oil, other market factors and seasonal trends, previous and current program period price movements and changes in margins were examined. Figure 4-1 shows Denver monthly average rack prices by grade. A two-year time span was selected to examine historical trends in Denver rack prices. Prior to and during the oxygenated fuels program Denver rack prices declined and then held steady.

Crude oil is a substantial component of the cost of gasoline. West Texas Intermediate (WTI) crude oil spot prices from January 1986 through February 1988 are also shown in Figure 4-1. WTI was recommended by the oil industry as being representative of U.S. crude oil price movements. Gasoline prices basically follow crude oil costs. Market imbalances rather than changes in component costs are attributed to the difference in rack and crude oil price trends.

Based on seasonal gasoline demand patterns, adjusted for crude oil price changes, one might expect Denver prices to rise in the summer with the high tourist demand in the rocky mountains and decline in the winter. Denver seasonal rack prices do not consistently follow this trend. Prices during the winter of 1986 were falling sharply; prices during the winter of 1987 were rising; and prices during the program winter of 1988 were steady. The previous seasonal price trends do not explain program price trends.

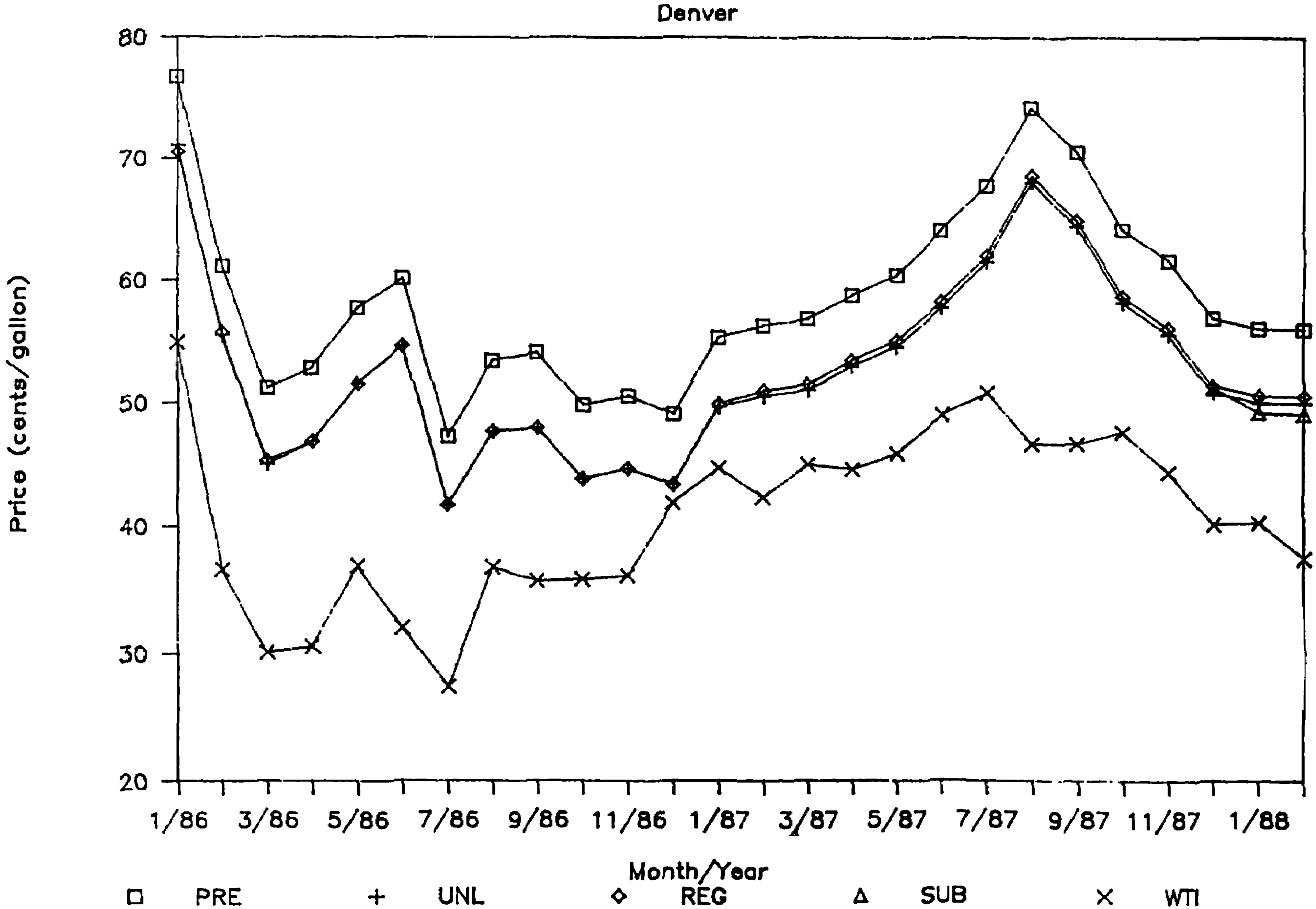
Despite large overall price fluctuations, the margins between grades in Denver have remained fairly stable. Regular leaded and unleaded prices remain very close with leaded gasoline slightly higher since January of 1987. Premium has been and continues to be priced 5 to 6 cents above regular and unleaded gasoline. Sub-octane gasoline used for blending with ethanol only became available in December 1987, in preparation of the program. The sub-octane was 1.5 to 2.5 points lower than standard octane or MTBE blended gasoline during the program and sold for half a cent to a cent less (the octane varied by source and time; the price by brand name). Based on octane value, the sub-octane would have been expected to cost even less than it did. Increased production, storage and distribution costs of separate clear grades of gasoline in addition to the full line of MTBE blends were cited for the small difference in sub-octane gasoline prices.

4.3.2 Comparison Cities

Based on the changes in Denver rack prices there was little or no cost increase of the program. However, because of other concurrent market changes

Figure 4-1

Rack Gasoline and WTI Crude Oil Prices



Source: Rock prices from Petroscan. Crude oil west Texas intermediate prices from the Oil and Gas Journal Energy Data Base.

(including crude oil and inventory changes) Denver rack prices should not be analyzed in isolation. Relative price analysis is necessary to determine if Denver prices significantly increased or decreased relative to other non-oxygenated fuel regions. Other city rack prices are compared with Denver for changes in relative prices, historical relationships, previous program period trends and actual program period price relationships. To have meaningful and accurate comparisons, other cities should track closely to Denver prices.

Rack price changes in Denver were compared with rack price changes in Kansas City, KS; Salt Lake City, UT; and Tulsa, OK to determine if program price changes can be separately identified and if so, how much prices before and during the oxygenated fuels program increased or decreased relative to other markets. These cities were selected for comparison based on gasoline supply and market similarities with Denver and based upon industry recommendations. A partial list of the attributes sought for comparison regions includes: a combination of refinery and pipeline supply; delivery from the same pipelines or refineries; similar market size; geographic locations in or influencing the rocky mountain region; and regions with little or no current oxygenate use. Representatives from the oxygenated fuels and oil industries indicated that no other city is directly comparable with Denver because of its unique market structure. However, at the Colorado Department of Health, February 4, 1988 Oxygenated Fuels Program meeting, industry representatives did agree that Denver prices should not be viewed in isolation and recommended that Kansas City, Salt Lake City and a mid-west petroleum producing city,such as Tulsa,would be the most suitable comparison cities.

Kansas City, Salt Lake City and Tulsa are connected by pipelines and/or the same refineries that supply Denver. Kansas City, Salt Lake City and Tulsa are roughly comparable in market size. The refinery at Eldorado supplies Kansas City by pipeline, ties into other mid-west pipelines and supplies Denver through the Chase pipeline. Tulsa, which is in Petroleum Administration for Defense District 3 and is part of "the Group" of interlinked oil producing cities, is considered representative of industry conditions because of its central location, supply of crude oil and extensive pipeline distribution system which interconnects Tulsa with other refineries and markets. Salt Lake

City is in the rocky mountain region and is served by the same refinery (Amoco in Casper, Wyoming) that supplies a substantial share of the Denver market via the WYCO pipeline. All of the comparison regions have little or no current oxygenate use. Other cities, such as Casper, Wyoming, are also connected to the Denver market, but were not used for comparison because they differ significantly in market supply, size and/or structure.

Each of the cities selected for comparison satisfies many of the criteria attributes. However, no city is exactly comparable with the Denver market. Gasoline markets are unique, and prices can and do change independently of other markets. Reasons for differential price changes, other than costs of the oxygenated fuel program, include: differences in refining and distribution costs, changes in inventories, changing price margins (profits), market competition and supply and demand imbalances. One attribute that distinguishes Denver from most other markets of the same size is its limitation in responding to supply-demand imbalances. Kansas City, Salt Lake City and Tulsa have the ability to import and export gasoline, while Denver does not. Denver is at the end of the pipelines and only imports gasoline.

Octane numbers in Denver and the rocky mountain region are two numbers lower for the same grades of gas than for the rest of the country. Octane numbers in the rocky mountains are 85 for unleaded, 87 for regular and 89 for premium. This precludes effectively comparing rack prices in Denver to those in other cities outside of the region.

4.3.3 Rack Price Changes in Comparison Cities

The reason for examining rack prices in comparison cities is to separate price changes due to natural market forces from program related price changes. Seasonal movements, relative city price relationships and monthly price variations are analyzed. Identifying these relationships and changes in the price are necessary to be able to verify estimates of program price impacts.

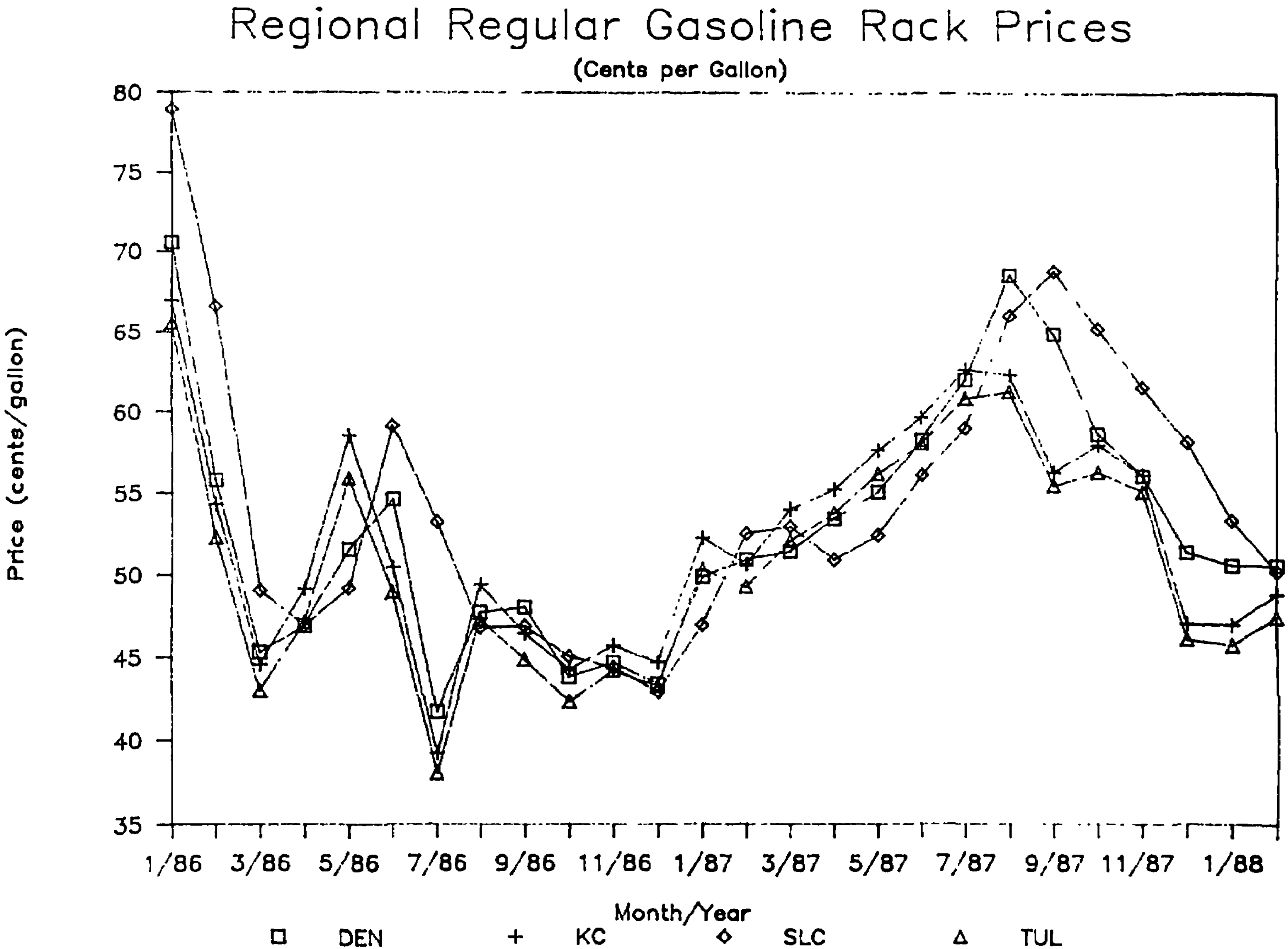
Over the past two years, with notable exceptions, overall rack prices in the comparison regions have tended to move together, obviously following major movements in crude oil prices and widespread market impacts. Figures 4-2, 4-3 and 4-4 show the monthly average rack prices for regular, unleaded and premium gasoline in Denver and the three comparison regions from January 1986 through February 1988. Rack prices of the different grades of gasoline change in a closely related manner. Because of this, and in order to simplify the discussion, only regular unleaded gasoline, which comprises the largest share of the market (53 percent; BBC 1987) is addressed in the subsequent discussion.

Two exceptions to the general trend of parallel movements in regional prices were when prices diverged in the summer of 1986 and diverged even more dramatically in the fall of 1987. Regional prices converged in the winter of 1986-1987 and appear to be converging again in the winter of 1987-1988. In discussions with the oil industry, no specific reasons could be given for the changes in these spreads or relative prices.

Seasonal changes in prices and gasoline demand were examined to see if they could explain variations in relative city prices. The volume of gasoline demanded in Denver increases with tourism in the summer and decreases in the winter. Prices would normally be expected to track with demand, however, rack prices have not consistently followed this seasonal pattern in previous program periods. Prices fell rapidly during the winter of 1986 and generally rose over the winter of 1987. In the fall of 1987, prices fell sharply, but, during the program, prices in Denver were steady and prices in two of the three comparison regions (Kansas City and Tulsa) were rising. Only in Salt Lake City, where prices had peaked one to three months after the other regions, were prices still falling. Seasonal price trends were not consistent in explaining relative rack price variation.

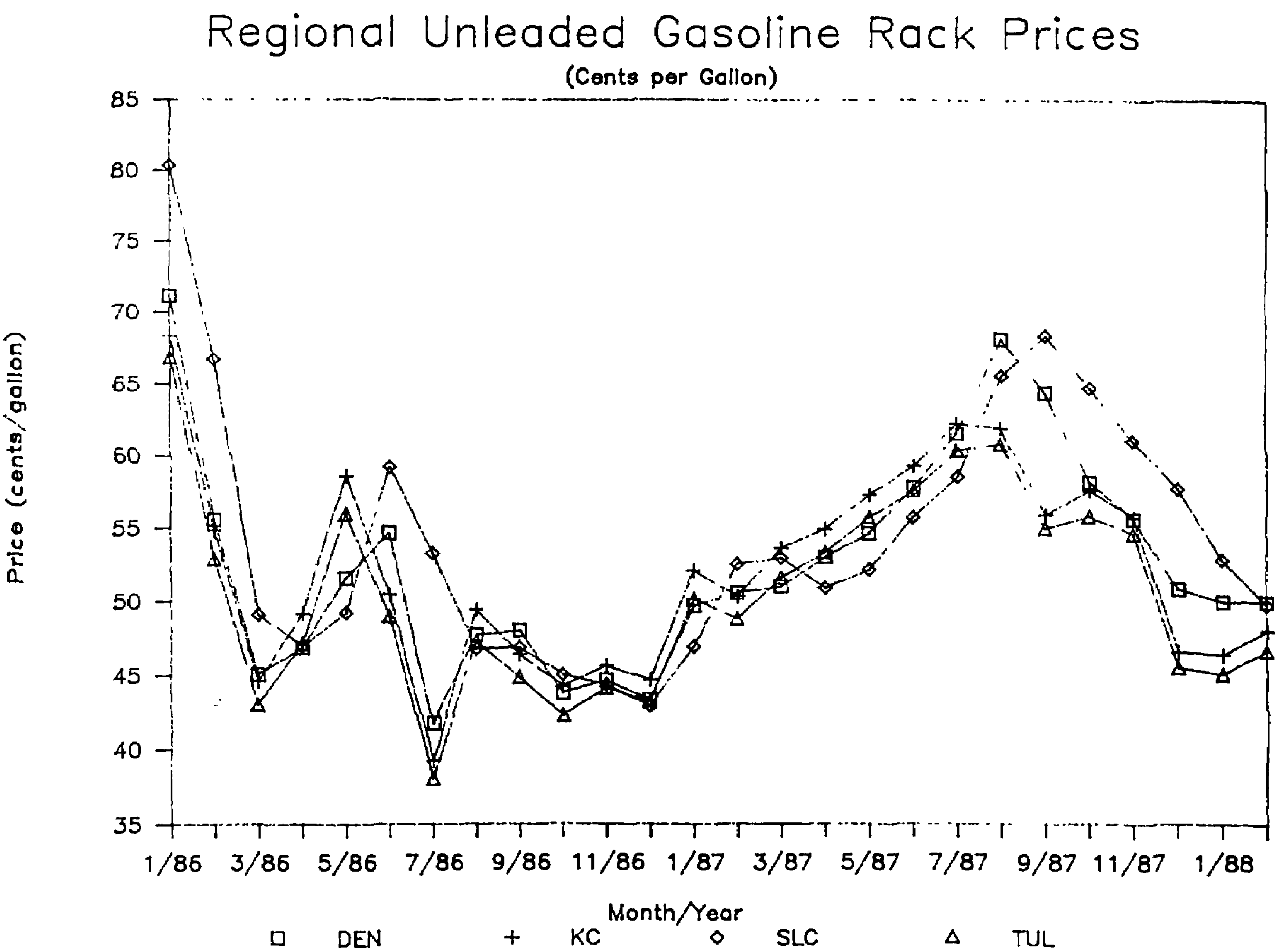
Considerable change has occurred in the relative rack prices among cities in the region. For example, during 1986 and the first half of 1987, Denver's rack price generally ranked in the middle of the comparison cities, but also ranged from the lowest prices (twice) to the highest prices (twice). In August of 1988, five months before the program, Denver rack prices were higher

Figure 4-2



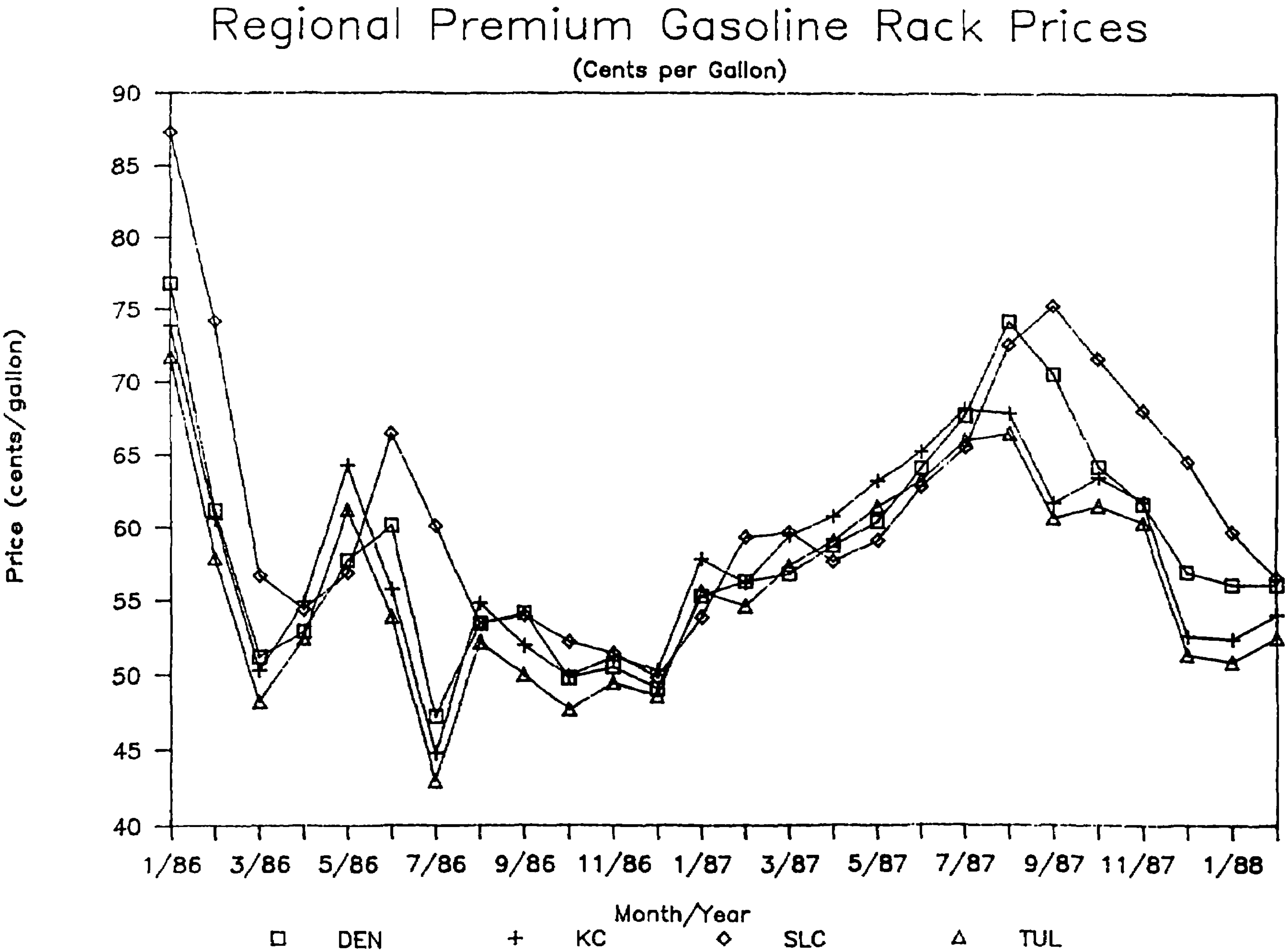
Source: Petroscan

Figure 4-3



Source: Petroscan

Figure 4-4



Source: Petroscan

than all of the comparison cities. After this peak, Denver prices fell rapidly and then leveled off.

Historically, the above type of relative price fluctuation is not unusual when comparing cities. This therefore limits the ability to detect relatively small price changes and assign the difference to any one source of impacts. In fact, to verify or quantify specific program impacts, the regional and temporal variability in prices must be smaller than the price impact to be identified.

Table 4-5 shows the inter-city difference in price as compared to Denver by month for 1986 through February 1988. Figures 4-2 to 4-4 and Table 4-5, show there are limited consistent relative price trends. Prices in each comparison city fluctuate from below and to above Denver prices over the course of a few months, apparently due to variability in local market pressures. The relative price changes can be quite large and do not follow simplistic patterns.

The rack price spread between the comparison cities is highly variable and has ranged from a high of 13.86 cents per gallon (1/1986, Tulsa-low and SLC-high) to a low of 2.6 cents per gallon (8/1986, SLC-low and KC-high) for unleaded gasoline. Immediately prior to the program, the price spread was 12.1 cents per gallon (12/87, Tulsa and SLC). In the last month of the oxygenated fuels program, Denver prices were just a quarter of a cent higher than SLC and the spread between the four cities had narrowed to only 3.26 cents per gallon, a change in the spread of almost 9 cents per gallon.

Month to month fluctuations in rack price in comparison cities as compared to Denver, are large. Historical variations in comparison city prices are much larger than the estimated impacts of the program. A comparison of the relative price differences in January of the program shows that they are not consistent with previous January price spreads but, are well within the range of observed historical price differences. It appears impossible to identify small (even the 3 to 6 cent pre-program estimates) short-term program related changes in rack price when there are larger non-program related price changes. Table 4-6 summarizes the variability in rack prices relative to Denver from

Table 4-5

Regional Price Differences Compared With Denver

(Unleaded Gasoline, Cents per Gallon)

Date	**Denver**	**Price Relative To Denver**		
		Kansas City	**Salt Lake City**	**Tulsa**
1/86	71.15	2.82	9.20	-4.30
2/86	55.56	-0.72	11.12	-2.68
3/86	45.06	-0.46	4.01	-2.02
4/86	46.85	2.31	0.09	0.28
5/86	51.57	6.98	- 2.37	4.39
6/86	54.64	-4.18	4.52	-5.69
7/86	41.74	-2.54	11.53	-3.72
8/86	47.69	1.72	- 0.92	-0.40
9/86	48.02	-1.59	- 1.15	-3.14
10/86	43.85	0.46	1.21	-1.51
11/86	44.70	0.97	- 0.29	-0.50
12/86	43.38	1.31	- 0.45	-0.12
1/87	49.68	2.44	- 2.73	0.49
2/87	50.58	-0.24	1.96	-1.77
3/87	51.05	2.60	1.94	0.61
4/87	53.04	1.89	- 2.12	0.33
5/87	54.66	2.63	- 2.46	1.09
6/87	57.77	1.53	- 2.04	-0.19
7/87	61.56	0.72	- 3.01	-1.16
8/87	68.11	-6.17	- 2.53	-7.29
9/87	64.45	-8.51	3.92	-9.44
10/87	58.18	-0.58	6.59	-2.34
11/87	55.64	0.12	5.45	-0.99
12/87	50.91	-4.25	6.81	-5.29
1/88	50.04	-3.57	2.84	-4.86
2/88	50.03	-1.95	- 0.24	-3.26

Source: Petroscan for monthly prices. Positive prices are above Denver, negative price below.

Table 4-6

Range in Regional Unleaded Rack Prices Compared to Denver

(Price Difference in Cents per Gallon)

Range in Prices	Kansas City	Salt Lake City	Tulsa
Jan 1986 - Feb 1988			
Above Denver	7.0	11.5	4.4
Below Denver	8.5	3.0	9.4
Range	15.5	14.5	13.8
Program Period Rack Price Relative To Denver			
Jan 1986	-2.8	9.2	-4.3
Jan 1987	2.4	-2.7	0.5

The range in prices represents Petroscan monthly price difference between Denver and each city.

January 1986 through February 1988. During this time, monthly price differences in the comparison cities have ranged from 9.4 cents per gallon below Denver to 11.5 cents per gallon above Denver.

The one-month fluctuation in Denver prices during the period 1/86-2/88 averaged 4.2 cents per gallon and ranged from 0.01 to 15.69 cents per gallon. Comparison cities one month price changes <u>relative</u> to Denver averaged 2.5 to 2.7 cents per gallon and ranged from 0.02 to 12.5 cents per gallon. The two-month fluctuation in relative prices averaged from 3.4 to 4.6 cents per gallon with a range of from 0.03 to 13.9 cents per gallon (see Table 4-7).

Again, this highlights the fact that large (relative to the projected program impacts) relative price impacts over short periods of time are common due to natural market forces suggesting that small relative price changes are not likely to be defensibly attributed to any one factor such as Regulation 13.

Because short-term price changes in comparison city prices do not track exactly with Denver, evaluation of program impacts based upon relative changes in prices are completely dependent on the time frame selected. During the program, Denver rack prices held steady in absolute terms and actually declined relative to two out of the three comparison cities. Kansas City and Tulsa prices increased by approximately 1.6 cents per gallon relative to Denver, while Salt Lake City prices declined by 3.1 cents per gallon relative to Denver. An analysis based only on rack price changes in these four cities during only the program months would indicate program benefits (relative price decreases in Denver) from blending with oxygenated fuels rather than costs, but again this is likely to be a spurious unsubstantiated result.

Comparing regional price changes over other time periods associated with the program yields a variety of different results and program costs (see Table 4-8). A comparison of regional price changes between December 1987, when fuel blenders began program implementation, and February 1988, the last month of the initial program, indicates that Denver prices declined relative to two out the three comparison regions. Between November 1987 and February 1988 rack

Table 4-7

Statistical Comparison of Rack Price Fluctuations

(January 1986 - February 1988)

	Kansas City	Salt Lake City	Tulsa
One-Month Average Change	4.7	4.4	4.4
Standard Deviation	4.0	4.1	3.9
One-Month Relative Average Price Change	2.7	3.1	2.5
Standard Deviation	2.7	3.0	2.4
Two-Month Relative Average Change	3.7	4.6	3.4
Standard Deviation	3.1	3.9	2.7
Three-Month Relative Average Change	3.6	4.7	3.3
Standard Deviation	2.6	3.9	2.5

NOTES: One-Month figure = changes in price spread between comparison city and Denver over a one-month period in absolute value. Two and three month price changes are calculated the same way.

Table 4-8

Regional Comparison of Changes in Rack Prices Over Time

Comparison Period	Change In Price				
	Denver	Kansas City	Salt Lake City	Tulsa	Comparison City Average
Jan-Feb 88					
Regular	0.06	1.83	-3.13	1.71	+ .14
Unleaded	-0.01	1.61	-3.09	1.59	+ .04
Premium	-0.02	1.64	-3.14	1.65	+ .05
Dec 87-Feb 88					
Regular	-0.82	1.76	-7.96	1.34	-1.62
Unleaded	-0.90	1.42	-7.93	1.15	-1.79
Premium	-0.88	1.45	-7.98	1.15	-1.79
Nov 87-Feb 88					
Regular	-5.52	-7.34	-11.33	-7.70	-8.79
Unleaded	-5.61	-7.69	-11.30	-7.88	-8.96
Premium	-5.59	-7.76	-11.48	-7.88	-9.04
August 87-Feb 88					
Regular	-17.99	-13.51	-15.82	-13.85	-14.43
Unleaded	-18.08	-13.86	-15.79	-14.05	-14.57
Premium	-18.15	-13.87	-16.05	-14.05	-14.66

Source: Petroscan, 1988.

prices in the three comparison regions declined approximately 1 to 3 cents more per gallon than the change in Denver prices. A comparison of regional price changes between August 1987, when market prices peaked, and February 1988 shows that Denver prices fell by 2.5 to 4.0 cents per gallon more than the prices in the other comparison cities.

4.4 DENVER RETAIL PRICES

Changes in costs that are common to producers, distributors or retailers are likely in large part to be passed on to the consumer in competitive markets through changes in retail prices. Although some companies may incur substantial individual costs that cannot be passed through to consumers, retail prices often reflect changes in costs to the industry as a whole. Changes in Denver retail prices are of interest in evaluating industry costs and consumer price impacts of program. Retail prices may also indicate if there were different impacts by type of blend.

Unfortunately, it is difficult to obtain timely, reliable retail price information and impossible to find retail price information by blend. One of the few available sources of Denver retail prices is the Rocky Mountain News, which conducts a weekly price survey of ten Denver stations. However, blends are not identified in the survey and the sample size is too small to provide reliable price comparisons. For these reasons, Hagler, Bailly initiated its own retail price survey to track gasoline prices by blend during the program.

The Denver Retail Price Survey

RCG/Hagler, Bailly Inc. conducted a bi-monthly survey in the Denver-metro area to track changes in retail gasoline prices, by grade and by blend, prior to and during the oxygenated fuels program. The Denver-metro area is the single largest retail market affected by the program with approximately 60 percent of the affected population (Denver Regional Council of Governments). A stratified sample of 106 retail stations was selected to be surveyed based upon the Colorado Oil and Gas Inspectors list of 760 retail stations in the

Metro-Denver area. The survey includes retailers in Denver, Aurora, Commerce City, Littleton, Englewood, Lakewood, Wheat Ridge, Arvada, Federal Heights, Thornton, Westminster, Northglenn and Boulder.

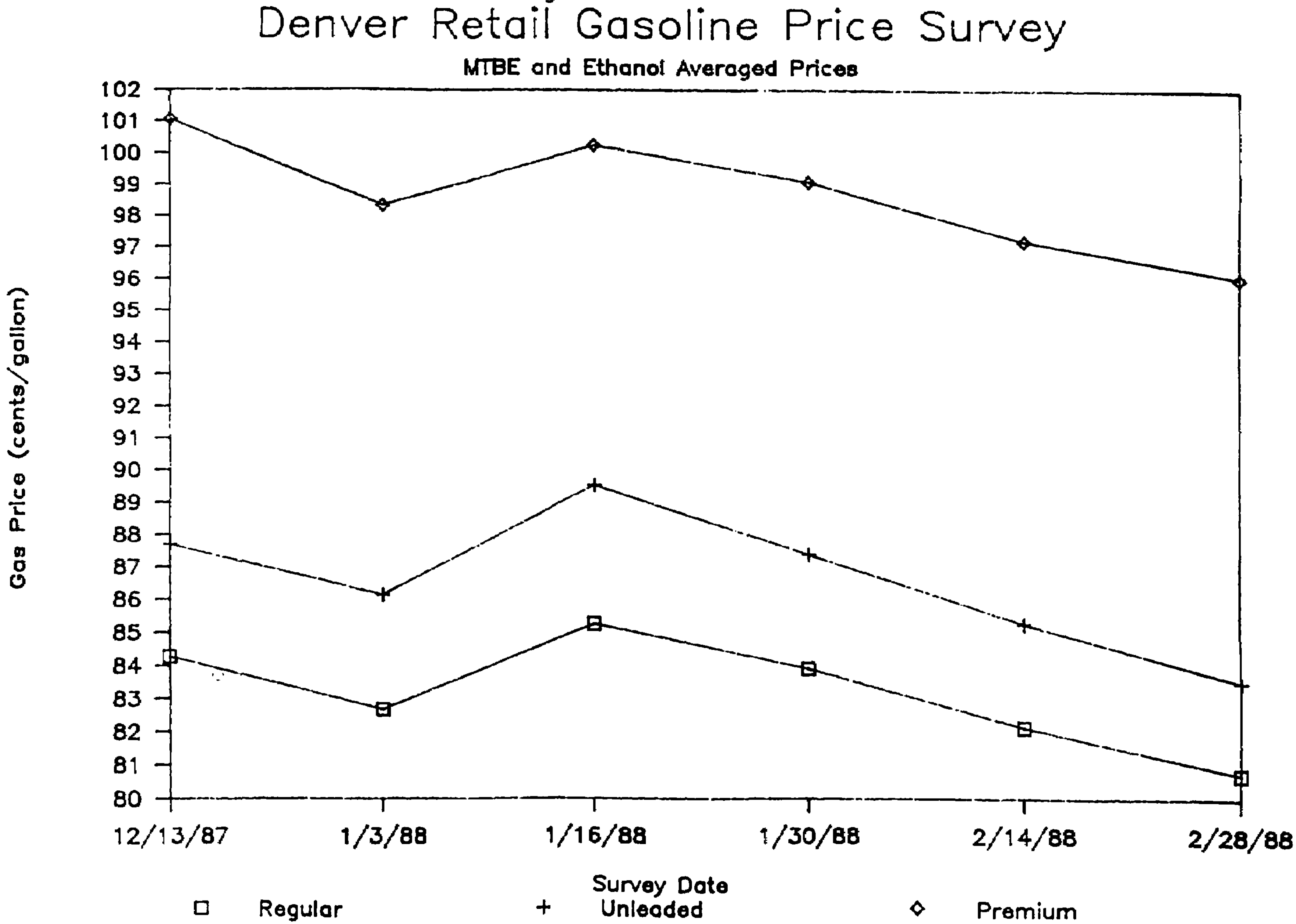
Retail prices by gasoline grade (regular, unleaded and premium) and by identified oxygenate blend (MTBE or ethanol) were collected every two weeks from December 13, 1987 through February 28, 1988. Only self service prices were collected to eliminate the wide variations in full service profit margins. The final survey captured approximately 14 percent of the Denver-metro market.

Results of the Denver Price Survey

Denver retail prices for both blends and all grades of gasoline declined during the oxygenated fuels program. Figure 4-5 shows the average price of MTBE and ethanol blends for regular, unleaded and premium gasoline by survey period. Prices fell as oxygenated blends were phased in during December, jumped by approximately of 3 cents per gallon in mid-January and then fell to below preprogram price levels. A comparison with movements in rack prices does not explain the sudden increase then decrease of Denver retail prices in January. Similar retail price movements are also observed in the Rocky Mountain News survey, as summarized in Figure 4-6, although the Rocky Mountain News Survey did not examine price movements by blend and only sampled ten stations in the Metro-area. The Rocky Mountain News retail survey prices differed from the Denver retail price survey by from +2.5 to -1.5 cents per gallon.

The Denver retail survey revealed a high correlation between station location and price. Stations located in close proximity almost always had comparable prices, regardless of the price level or oxygenate used, while prices between locations varied widely. The existence of many local competitive markets underlines the importance of having a large sample size and a widely distributed survey.

Figure 4-5



Source: RCG/Hagler, Bailly, Denver Retail Price Survey

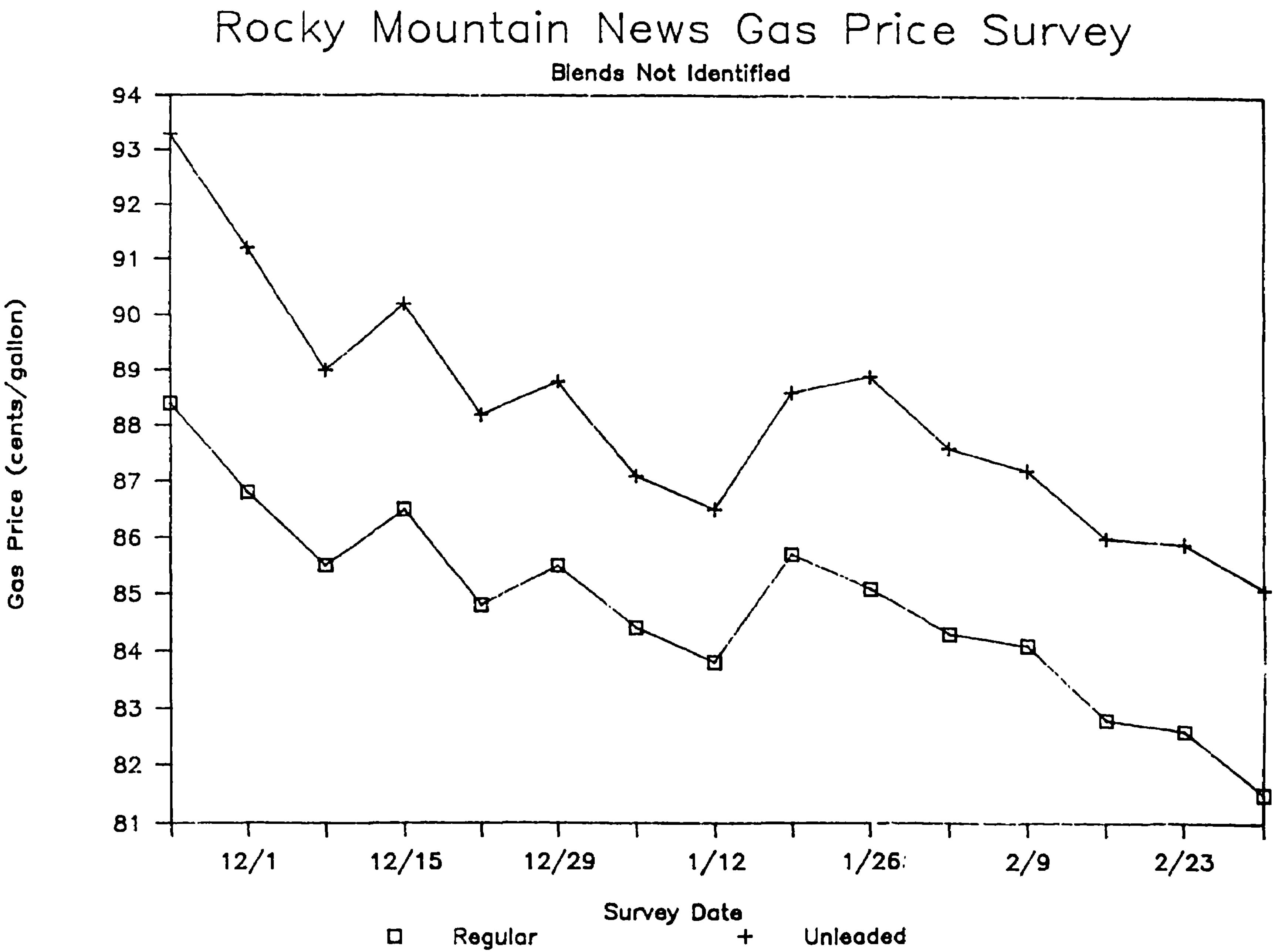
Denver retail prices declined prior to and overall during the oxygenated fuels program. During the program period (January 1 through March 1), the average price of both oxygenate blends declined by 1.92 cents per gallon for regular, 2.58 cents per gallon for unleaded and 2.29 cents per gallon for premium (see Table 4-9). A decline of from 1.6 to 2.7 cents per gallon was also observed immediately prior to the program. To measure consumer price impacts of the program with retail prices, changes in retail prices should be directly linked with changes in rack (industry) prices. Over the December through February period, rack prices only declined by about two cents per gallon, less than the 4 to 5 cent drop in retail prices. However, this smaller change in rack prices follows a sharp drop in rack prices throughout the fall. Hypotheses about the difference between program period retail and rack price movements include: that retail prices lag behind changes in rack prices; that inventories built up at the retail level; and that retail competition increased, resulting in reduced retailer profit margins. In either case, changes (decreased) in retail prices are larger than the changes (decrease) in rack prices and therefore cannot be used to reject above engineering costs estimates of the relative small program costs.

Other retail market changes occurred during the program, which also made it difficult to distinguish program related impacts. Regular gas (without oxygenated added), which has traditionally been priced below unleaded gasoline at the retail level, was at some retail stations priced the same as or above unleaded gas during the program. Regular gas has been and is priced slightly higher at the wholesale level. The pricing change brings the regular-unleaded retail price spread in line with the rack price spread. Changes in gasoline grades have also ocurred. Texaco has discontinued distributing regular leaded gasoline and is selling a mid-grade (87 octane in Colorado) unleaded gasoline in its place. The midgrade gasoline was excluded from the survey.

Differences in Blended Gasoline Prices

There were significant differences between the prices of oxygenate blends. Figures 4-7, 4-8 and 4-9 and Table 4-9 show the average prices of MTBE and ethanol blends by grade of gasoline. Ethanol blends were lower in price for

Figure 4-6

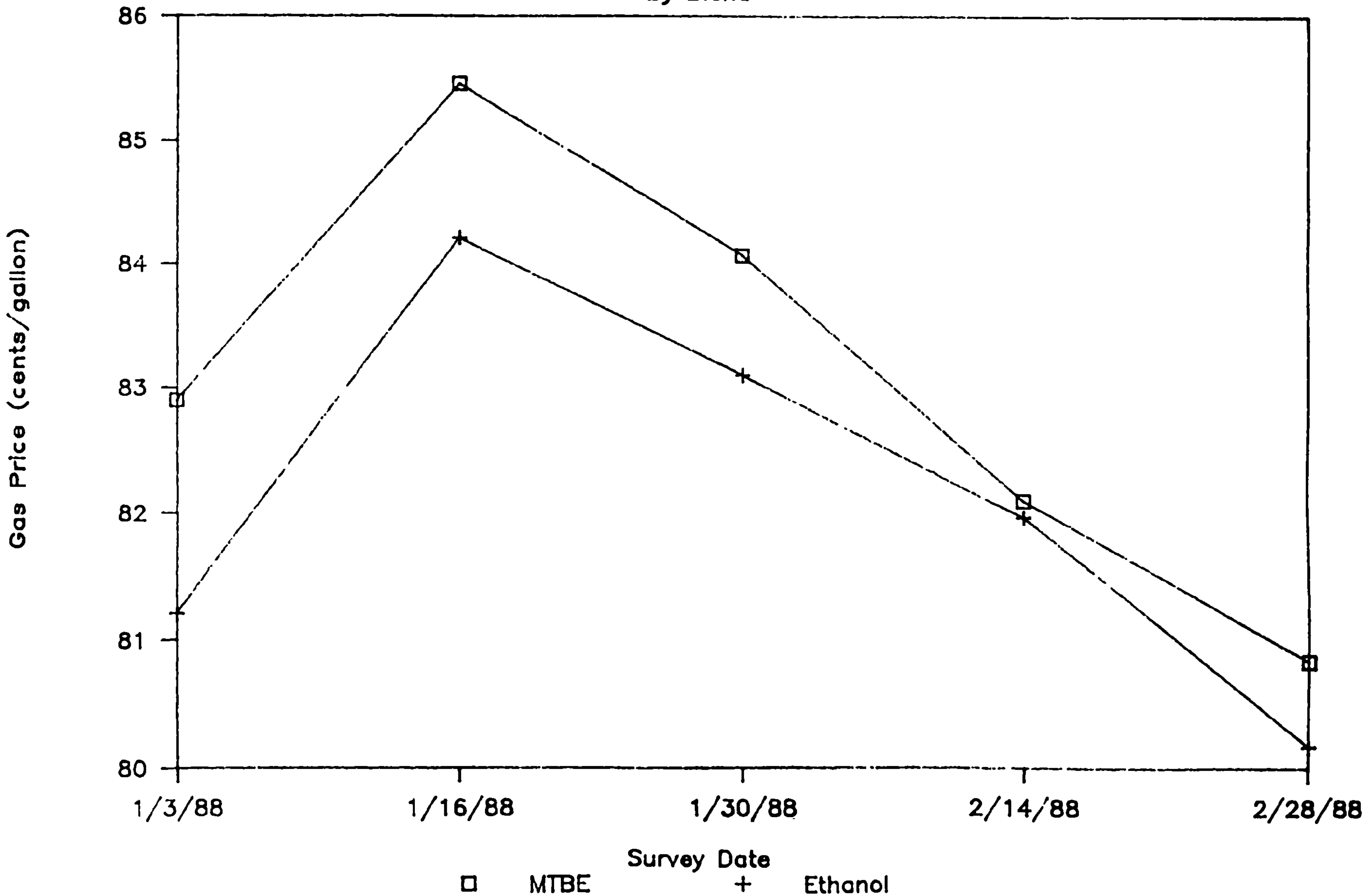


Source: Denver, Rocky Mountain News

Figure 4-7

Denver Regular Retail Gasoline Prices

By Blend

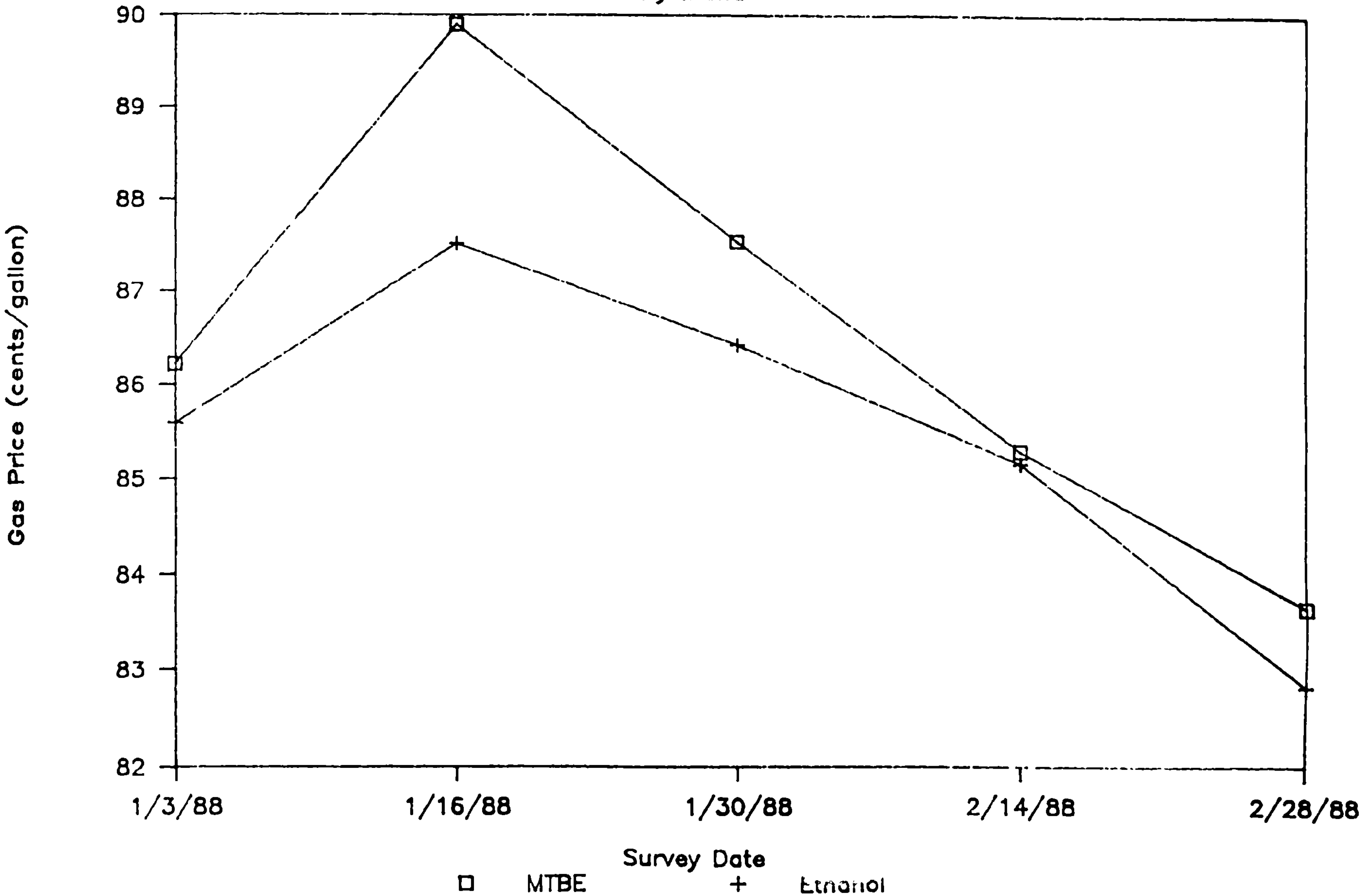


Source: RCG/Hagler, Bailly, Inc., Denver Retail Price Survey

Figure 4-8

Denver Unleaded Retail Gasoline Prices

By Blend

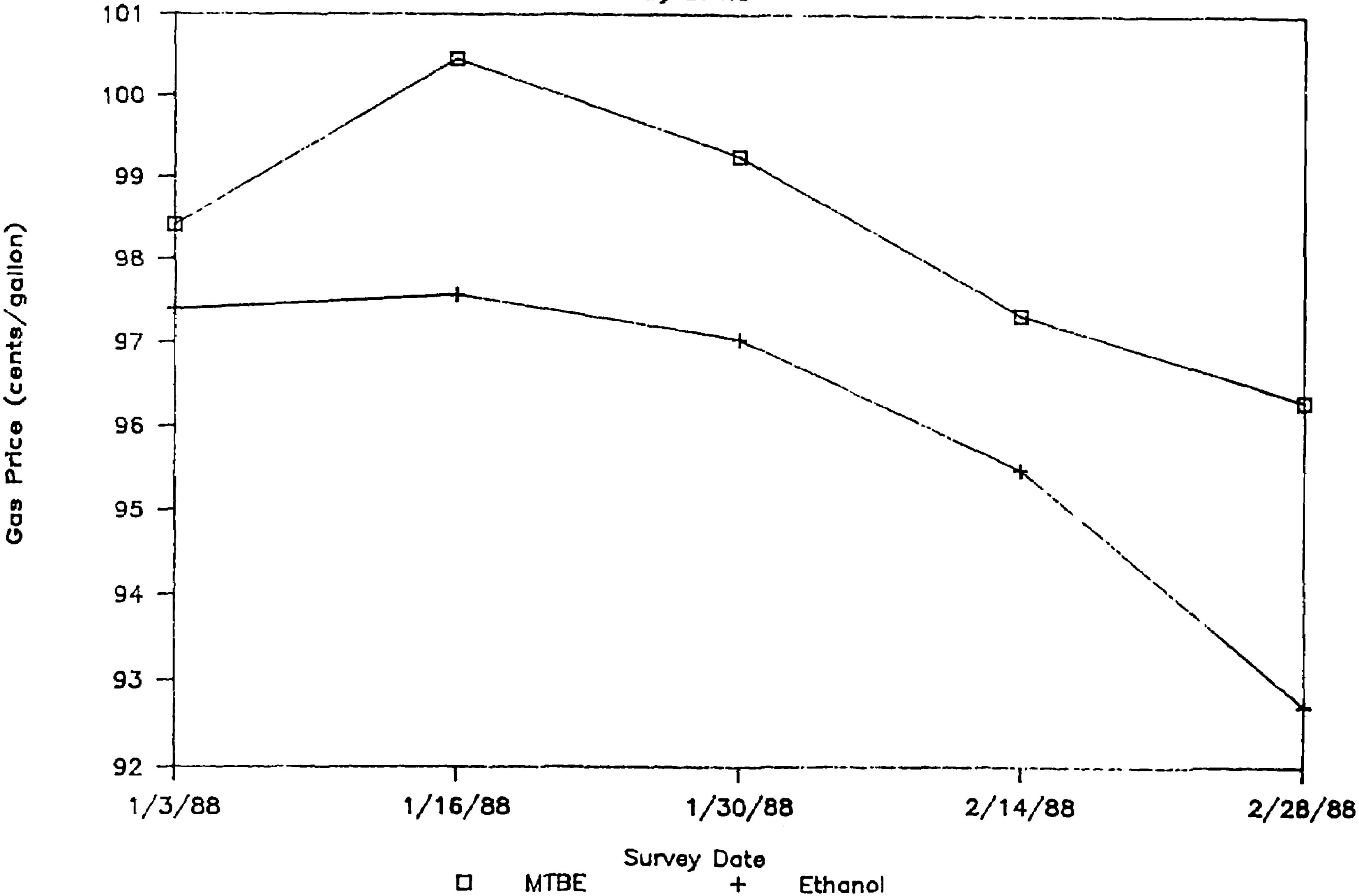


Source: RCG/Hagler, Bailly, Denver Retail Price Survey

Figure 4-9

Denver Premium Retail Gasoline Prices

By Blend



Source: RCG/Hagler, Bailly, Denver Retail Survey

Table 4-9

Summary of the Denver Retail Price Survey

Prices in Cents Per Gallon

Grade and Blend	Average Price By Survey Date: Dec. 13	Jan. 3	Jan. 16	Jan. 30	Feb. 14	Feb. 28	Pre-Program Price Change Dec.13-Jan.3	Program Price Change Jan.3-Feb.28
REGULAR	84.28	82.66	85.28	83.93	82.14	80.74	-1.62	-1.92
MTBE	*	82.90	85.46	84.07	82.10	80.84	*	-2.06
Ethanol	83.90	81.21	84.21	83.10	81.97	80.17	-2.69	-1.04
Observations	85	86	88	102	103	103		
UNLEADED	87.71	86.13	89.56	87.40	85.29	83.55	-1.58	-2.58
MTBE	*	86.22	89.90	87.54	85.30	83.67	*	-2.55
Ethanol	87.26	85.59	87.52	86.43	85.17	82.83	-1.67	-2.76
Observations	89	89	91	106	106	106		
PREMIUM	101.07	98.34	100.26	99.10	97.21	96.05	-2.73	-2.29
MTBE	*	98.41	100.46	99.26	97.34	96.31	*	-2.10
Ethanol	98.50	97.40	97.57	97.04	95.50	92.70	-1.10	-4.70
Observations	58	57	59	69	69	69		

Source: RCG/Hagler, Bailly Inc. Denver Retail Price Source, The gasoline grade average is for all blends in the sample

* Less than 2% of the stations reported having MTBE in the December 13 price survey.

all grades. Premium gasoline had the largest price spread between blends ranging from 1.8 to 3.6 cents per gallon. The price spread between MTBE and ethanol blends was about the same for regular and unleaded gasoline. The spread between unleaded gas blends increased in mid-January to about 2.4 cents per gallon along with the increase in prices, decreased to about 0.1 cents per gallon in mid-February as retail prices fell and then increased to about 1.0 cents per gallon by the end of February.

While a difference in blend prices was to be expected because of the way ethanol blends are priced, reasons for the changes in the price spreads are uncertain. Ethanol blends are generally priced approximately 2.0 cents per gallon less than other gasoline at the wholesale level. Retailers have the option of passing on this savings, minus additional ethanol related costs such as tank preparation, or increasing their retailer profit margin. One consequence of this pricing policy is that the rack price of ethanol blends will follow the rack price of other gasoline. If MTBE gasoline prices increase so will rack prices of ethanol blends. Increased competition in the retail market may pressure prices closer together, reducing profit margins and narrowing the spread. Ethanol blend retailers have indicated that they price in competition with the stations in their local area, maintaining their profit margin if possible but, if competition demands it, they will lower prices passing some of the savings on to the consumer. The competitive local pricing observed in the Denver retail survey provides evidence of this type of behavior.

4.5 REGIONAL COMPARISON OF RETAIL PRICES

Retail prices in Denver were compared with retail prices in Kansas City, Salt Lake City and Tulsa to determine if prices before and during the oxygenated fuels program increased or decreased relative to other cities. These cities were selected for comparison based on industry recommendations of comparability and similarities in market structure, a combination of refinery and pipeline supply, service by the same pipelines supplying Denver, geographic location and market size (see Section 4.3 for more detail on comparison city selection).

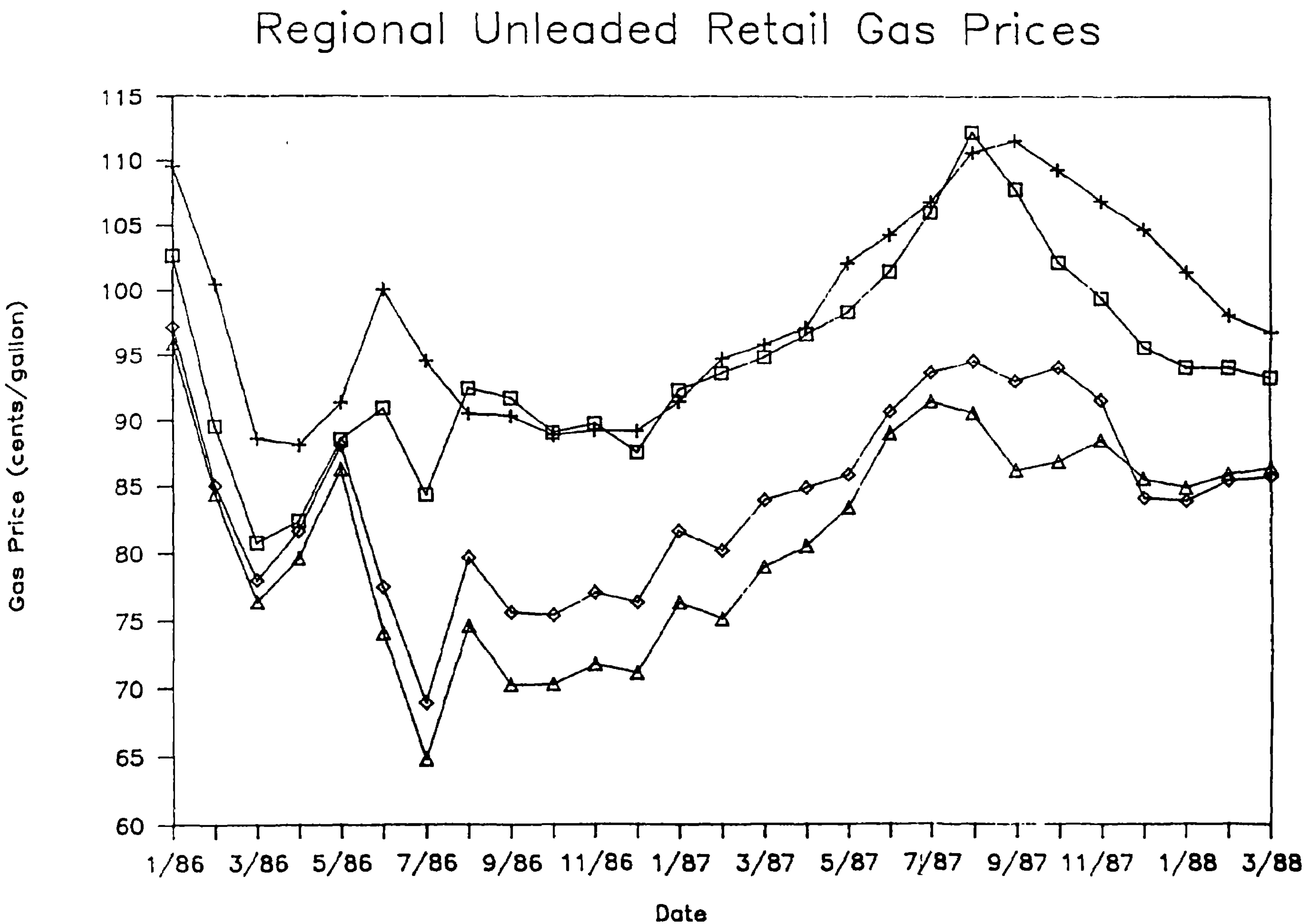
There are very few sources of timely retail price information available. Retail information collected by the U.S. Department of Energy and published in the Monthly Refinery Report is not available until three to five months after the survey period. Retail unleaded gasoline prices for the four comparison cities for January 1986 through February 1988 were available from the Oil and Gas Journal. This data provides a good indication of price trends, but it is not as reliable in providing precise prices because the data is adjusted using changes from base retail price levels.

More than two years of data were used to evaluate historical retail price relationships between cities. Figure 4-10 shows the monthly unleaded retail prices for Denver and the three comparison cities.

Retail prices over the past two years have followed the same general trends in all four regions reflecting major fluctuations in the price of crude oil. Kansas City has usually had the lowest retail prices, followed by Tulsa, Denver and Salt Lake City. Prices in Denver and Salt Lake City increased relative to Kansas City and Tulsa during the summers of 1986 and 1987. After the 1986 increase, Denver prices tracked at a level more closely with Salt Lake City than with Kansas or Tulsa. This can be attributed in part to a July 1, 1986 six cent per gallon tax increase in Colorado that brought Denver retail prices nearer to the level of Salt Lake City. After tracking more closely with Salt Lake City prices in August of 1987, Denver prices started falling more rapidly, diverging from Salt Lake City prices. Salt Lake City prices were still falling during the program but, remained above Denver prices. Kansas City and Tulsa price levels compared to Denver also fluctuate over time. The fluctuations in intercity retail prices make it impossible to quantify impacts that may be attributable to the oxygenated fuels program.

Retail price changes do not consistently follow the wholesale cost of gasoline on a month-to-month basis. Comparisons of retail and rack prices in each region yielded widely fluctuating price margins that did not follow a

Figure 4-10



Source: Oil and Gas Journal Energy Data Base consistent pattern over time. The fluctuations in retail-rack price margins and changes in the relative city retail prices make it virtually impossible to identify program related retail costs with this data.

4.6 FUEL ECONOMY PENALTY

Throughout the Regulation 13 rulemaking there has been concern that the program could increase gasoline consumption and create additional expenses for consumers. As recently as March 29, 1988 Denver newspapers reported a petroleum industry analysis which estimated a mileage penalty of 55.6 million. dollars / miles / gallons ?

An analysis of the literature on oxygenated fuels and gasoline consumption by the Colorado Department of Health concluded that the type of pollution controls on an automobile determines the effect oxygenated fuels has on gasoline consumption (Colorado Department of Health, 1987). Using the Health Department figures, fuel economy losses are calculated in relation to fleet composition, the mileage penalty associated with a particular control-technology and market share of oxygenates during the program.

As Table 4-10 illustrates, the fleet mix and Colorado Department of Health assumptions on fuel economy changes shows an average fuel economy change of less than one percent. Using the January and February statewide gasoline consumption figures of 329.4 million gallons, an average price of about $0.87 per gallon and the worst case fuel penalty scenario of 0.22%, the cost to consumers was $420,000. Equivalently, one could consider each gallon of gas as, on average, having 0.22% or a $0.002 reduction in value during the first year of the program.

Table 4-10

Fuel Economy Changes

Control Technology	% of Fleet	% Changes in Fuel Economy	
		MTBE	Ethanol
Non-Catalyst	34%	0.0%	-0.3%
Catalyst	41%	+1.3%	+0.3%
Closed Loop	25%	-1%-3%	-0.3%
Weighted Average:	100%	-.22% to +.28%	-.05%

Source: Estimates of percent change in fuel economy from the Colorado Department of Health, 1987.

4.7 OTHER SOCIAL IMPACTS AND COSTS

Industry Administrative Costs

In January, 1988 approximately 8.4 million gallons of MTBE was transported into Colorado either by rail or, when blended with gasoline, via pipeline. Gasoline containing MTBE was transported through the Chase and Phillips pipelines (30 percent of the Colorado market). The remaining 5.88 million gallons (70 percent of total MTBE sales) was transported to Colorado or Wyoming for blending in approximately 200 rail cars (30,000 gallons per car). The incremental rail costs are incorporated into the MTBE production cost estimates in Section 4.1. However, gasoline marketers who obtained MTBE by rail were inconvenienced by the logistical difficulties of obtaining shipment of MTBE. The gasoline distributors were confronted with the unavailability of MTBE shipments and were occasionally forced to borrow MTBE from other distributors until a shipment arrived.

Governmental Costs

The Colorado Department of Health and the Oil and Gas Section of the Department of Labor incurred costs enforcing Regulation 13. The Health department purchased new equipment to test for oxygen content and hired staff take fuel samples and to respond to inquiries on their telephone Hotline.

Costs Outside The Program Area

Almost all of the gasoline sold in Colorado contained oxygenates. Any costs associated with the program were borne by all Coloradans. However, some motorists in non-program areas used clear gasoline, which had been trucked in from out-of-state (see Section 3.3) adding transportation costs over the normal delivery procedures. Clear gasoline generally sold at a price equal or exceeding MTBE blended gasoline (Conversations with industry representatives), rather than below MTBE blended gasoline, as might have occurred without the program. Assuming 8.6 million gallons sold during the program at a price penalty of up to $0.013 (maximum MTBE price increase) results in an added cost during the first program year of $112,000. If there is a strong demand for clear gasoline in future years, petroleum marketers should be able to provide the product.

Maintenance Costs

Testimony given prior to and during the rulemaking established the possibility that use of oxygenated fuels would result in some driveability problems and maintenance expenses (clogged fuel filters, deterioration of rubber parts). The Department of Health Hotline, and an informal tracking of fuel related repairs by the Automobile Association of America did not reveal any quantifiable increase in maintenance costs caused by the use of oxygenated fuels.

Potential Increases In Ozone

Testimony was presented prior to and during the rulemaking that a large year-round penetration of ethanol could increase hydrocarbon emissions, and exacerbate the existing summer time ozone problem. Analysis by the Colorado Department of Health has concluded that even with a 100 percent penetration of ethanol (exempted from ASTM) during the non-winter months, the overall increase of evaporative emissions would increase ozone from the current highest recorded levels of 0.13-0.15 parts per million to 0.15-0.17 PPM (Colorado Department of Health, 1985).

5.0 Summary of Economic Impacts

Table 5-1 summarizes the range of costs estimates of Colorado's first year Regulation 13 program. Total costs statewide ranged from $1,013,481 (central bound estimate) to no more than $3,559,604 (upper bound estimate). The lower bound estimates are zero. Program costs varied by oxygenate blend. MTBE blends comprised about 95% of the gasoline sold in the program area.

The costs were largely incurred by Colorado residents in the AIR area (72%), although residents in non-program areas may have incurred costs due to the Colorado petroleum distribution structure resulting in most of the state converting to oxygenated fuel. These costs are included in both the central and upper bound estimates. The central average price increase per gallon attributable to the program is $0.0046, the cost per program area household is $0.87.

The economic impacts estimated in this costing analysis, which are based upon incremental capital equipment and blending costs are not rejected by careful examination of rack prices in Denver and other cities. No substantive increase in Denver rack prices relative to comparison cities can be defended. In fact, if price trends are analyzed in the cities recommended by the petroleum and oxygenate industries (Section 4.3.2), Denver's prices during the program months appear to decline relative to those cities. However, it is important to note that the intrinsic, relative short-term fluctuation in rack prices across regional cities due to local market forces is of such magnitude that small short-term impacts due to a program like Regulation 13 are unlikely to be defensibly quantified using this approach. Therefore, the recent estimates by EAI (1988) are likely to have little or no statistical validity. In fact, alternative analysis of their data indicates numerous alternative conclusions, all with little or no statistical power.

Table 5-1

Summary of Colorado's Oxygenated Fuels Program Costs

($ 1988)

Cost Category*	Dollars		Dollars/Gallon	
	Central Cost Estimate	Upper Bound Estimates	Central Estimates	Upper Estimates
MTBE				
Capital Equipment	$ 110,044	$1,031,546	0.0005	0.0049
MTBE Purchase	4,198,100	5,037,720	0.020	0.024
Octane Value Added	-3,358,480	-3,358,480	-0.016	-0.016
Total MTBE Cost	949,664	2,710,786	0.0045	0.0129
Ethanol				
Cleaning Costs	1,017	29,260	0.0003	0.009
Market and Octane Costs	62,800	282,575	0.0066	0.03
Total Ethanol Costs	63,817	311,835	0.0069	0.039
Clear Gasoline	0	112,463	0	0.013
Fuel Economy Penalty	0	424,520	0	0.002
Total All Gasoline*	$ 1,013,481	$3,559,604	0.0045	0.016

Cost Impacts By Location

Area and Impact		Dollars	
		Central Case Estimates	Upper Bound Estimates
AIR AREA	- Total $	$763,837	$2,615,536
	- $/Gallon	$0.0046	$0.0159
	- $/Household	$0.868	$2.97
REST OF STATE	- Total $	$249,644	$943,968
	- $/Gallon	$0.0039	$.0148
	- $/Household	$0.729	$2.75

* Total costs statewide. Sales volume during the two-month program: ethanol 9,419,000; MTBE 209,905,000; and Clear Gasoline 8,651,000.

Cost Per Ton of Pollutant Removal

The Colorado Department of Health has estimated that a 94% market share of 8% MTBE and 6% market share ethanol (10%) reduced ambient Carbon monoxide levels in the Denver Metropolitan area from 8% to 11%, or from 160 to 220 tons per day. Using state-wide central and upper case cost estimates, and applying the carbon monoxide reductions to five days a week, the dollar per ton cost of the program would be $154.49/ton (Central estimate) to $542.62/ton (upper-bound estimate) for an 8% reduction and $112.36/ton to $394.63/ton for an 11% reduction.

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APPENDIX A

APPENDIX A

List of Persons Interviewed

RCG, Hagler, Bailly would like to express its appreciation to the following people who generously provided us with invaluable information.

Individual	Company
Mike Barwig	Spruce Oil
Barbar Bauerle	Automobile Association of America
Ken Buckler	Total Petroleum Inc.
Pete Coggeshall	Amoco Corporation
Vern Combs	Pennzoil Products Company
Dick Coven	Sinclair Oil Company
Jan Cool	Exxon
Dennis Creamer	Conoco Inc.
Tom Dunn	Colorado Department of Revenue
Dick Ervin	Texaco
Jerry Gallagher	Colorado Department of Health
Ron Hagmier	Ventra, Inc.
Ted Holman	Colorado Department of Health
Lance Hoboy	Vestec Petroleum
Loren Hoboy	Western Refining
Jim Kaiser	Sinclair Oil Company
Jeff Kramer	Frontier Oil and Refining
Tom Lareau	American Petroleum Institute
Jerry Levine	Amoco Corporation
Kim Levo	Colorado Department of Health
Sandra Nobbe	Oil and Gas Journal
Stan Lomax	Texaco
Bob MeHall	Diamond Shamrock
Dave Meyers	Conoco Inc.
Bill Piel	ARCO Chemical Company
Dick Piper	Phillips 66 Company
Mike Powell	Colorado Department of Labor, Oil Inspection Section
Joe Scott	Chase Transportation
John Snodgrass	Diamond Shamrock
Patty Stolp	Ethanol Managment Company
Jim Suttle	Chase Transportation
Rod Voight	Archer Daniels Midland
Jack Wilkins	Kubat Equipment
Ron Williams	Gary Refining
George Wright	Coors
Darcy Wold	Total Petroleum Inc.
George Yogis	ARCO Chemical Company

APPENDIX B

REGULATION NO. 13

"The Reduction of Carbon Monoxide Emissions from Gasoline Powered Motor Vehicles through the use of Oxygenated Fuels"

OXYGENATED FUELS PROGRAM

I. Statement of Intent, Area of Application, and Definitions

A. Statement of Purpose

The purpose of this regulation is to reduce carbon monoxide and particulate emissions from gasoline powered motor vehicles in the AIR Program area through the winter time use of oxygenated gasolines. The attached Statement of Basis, Statutory Authority and Purpose, and Fiscal Statement are incorporated herein, for the purpose of reference only, as Sections IV. and V., respectively.

B. Area of Application

This regulation shall apply to the AIR Program area as defined in C.R.S. 42-4-307 (11).

C. Definitions

The following terms shall have the following meaning when used in this regulation:

1. "AIR Program" means those parts or all of Colorado's Front Range counties as defined in C.R.S 42-4-307 (11).

2. "Commission" means the Colorado Air Quality Control Commission.

3. "Division" means the Air Pollution Control Division of the Colorado Department of Health (CDH).

4. "Motor Vehicle" means any self-propelled vehicle which is designed primarily for travel on the public highways and which is generally and commonly used to transport persons and property over the public highways. For the purpose of this regulation, motor vehicles shall refer to spark ignition motor vehicles which use on a part or full time basis, gasoline or gasoline-type products.

5. "MTBE" means methyl-tert-butyl-ether.

6. "Oxygenated Fuels" means gasolines blended with a component or components containing oxygen, generally an alcohol or ether.

7. "Class A Motor Fuel" means any gasoline type product as defined in C.R.S. 8-20-202.

II. REQUIREMENTS OF THE OXYGENATED FUELS PROGRAM

A. Class A Fuel Requirements

1. Beginning January 1, 1988, to March 1, 1988, no Class A motor fuel shall be supplied or sold by any person intended as a final product for fueling of motor vehicles within the AIR Program Area, or sold at retail, or sold to a private fleet for consumption, or introduced into a motor vehicle in the AIR Program area by any person, unless the fuel has at least a 1.5% oxygen content by weight. Oxygenated fuel containing 8% by volume MTBE shall be considered equivalent to 1.5% oxygen content by weight.

2. Beginning November 1, 1988, to March 1, 1989 and for each period of November 1 to March 1 thereafter, no Class A motor fuel shall be supplied or sold by any person intended as a final product for fueling of motor vehicles within the AIR Program area or sold at retail, or sold to a private fleet for consumption, or introduced into a motor vehicle in the AIR Program area by any person unless the fuel has at least a 2.0% oxygen content by weight. Oxygenated fuel containing 11% by volume MTBE shall be considered equivalent to 2.0% oxygen content by weight.

3. All oxygenated motor fuel shall be labeled at the pump during the periods stated in Sections II.A.1. and II.A.2., identifying the type and amount of oxygenate contained in the motor fuel, in accordance with labeling criteria developed by the Division consistent with any applicable law.

B. Reporting and Review Requirements

1. The Air Pollution Control Division, in consultation with the State Oil and Gas Inspection Section, the Environmental Protection Agency, the fuel refiners, oxygenate manufacturers, marketers and retailers, the Colorado Auto Dealers, lead air quality planning agenices, motorists and environmental organizations, shall prepare a report, to be filed with the Commission, on April 15 of each year regarding the results of the Oxygenated Fuels Program, with particular attention to a cost/benefit analysis, to include such factors as air pollution reductions obtained from the program, driveability problems, if any, the cost of the program to motor vehicle owners, refiners, marketers and retailers of the fuel, and other information which is relevant to whether the oxygenated fuels program should be continued. The Division shall also work with all appropriate entities to develop and implement a public education program.

2. At its May meeting of each year, the Commission shall consider, in light of the report and other available information, whether the oxygenated fuels program should be modified, expanded, or terminated by rule, and the Commission shall transmit to the General assembly the report of the Division and the results of the Commission's consideration.

C. Enforcement/Penalties for Non-Compliance

Compliance with the requirements of this regulation shall be monitored and enforced by the Division. Tolerance for measurements of fuels defined in Section II.A.1. and 2. shall be determined by the Division and shall be consistent with reasonable practices. Pursuant to Section 25-7-111(f), the Division may designate any appropriate agency of the State to assist in the monitoring and enforcement of this regulation. The Division shall make every effort to coordinate monitoring and enforcement of this regulation with the current duties of the State Inspector of Oils, conducted pursuant to C.R.S. 8-20-101 et seq.

D. Severability

The provisions of this regulation are severable, and if any provisions, or the application of the provisions to any circumstances, is held invalid, the application of such provision to other circumstances and the remainder of this regulation shall not be affected.

III. REFERENCED MATERIAL

Pursuant to C.R.S. 24-4-103 (12.5), the following materials referenced in this regulation are available for public inspection during normal working hours, or copies are available upon request at cost, from the Technical Secretary of the Air Quality Control Commission, Ptarmigan Place, 3773 Cherry Creek Drive North, 3rd floor, (303) 331-8597: C.R.S. 42-4-307 (11), C.R.S. 8-20-202, C.R.S. 8-20-204, C.R.S. 8-20-229, C.R.S. 24-4-103(12.5), C.R.S. 6-4-101 et seq, C.R.S. 25-7-111(f), C.R.S. 8-20-101 et seq.

IV. STATEMENT OF BASIS, SPECIFIC STATUTORY AUTHORITY AND PURPOSE

The primary purpose of Regulation No. 13 is to reduce ambient levels of carbon monoxide along the Front Range of Colorado. To achieve this reduction, Regulation 13 will institute an oxygenated fuels program throughout the AIR Program area during the period of January 1 to March 1 of 1988, and for each period of November 1 to March 1, thereafter. The Commission has determined that a voluntary program from November 1, 1987 through December 31, 1987 would be of great benefit to the public and will result in air quality benefits by reducing carbon monoxide, and directs the Division to proceed with coordinating and implementing such a voluntary program.

An oxygenated fuels program is a necessary step for Colorado to attain the National Ambient Air Quality Standard (NAAQS) for carbon monoxide. Of primary concern is the eight hour, long term carbon monoxide standard, which provides for an eight hour carbon monoxide limit of 9 PPM. Having more than one exceedance of this standard per year constitutes a violation of the carbon monoxide NAAQS. Areas along Colorado's Front Range, especially in Denver, have consistently failed to meet this standard.

Use of oxygenated fuels reduces carbon monoxide emissions from gasoline powered motor vehicles. The technical basis for this determination is as follows:

- Most carbon monoxide emissions along Colorado's Front Range are from motor vehicles. It is estimated that in 1987, 77% of the areas CO emissions are from motor vehicles.

- Oxygenated fuels, containing oxygen via an alcohol or ether blended with gasolione, have been shown, through testing by CDH and others, to be effective at lowering carbon monoxide emissions from motor vehicles. Reductions are directly attributable to the oxygen contained in these fuels, by leaning the air/fuel ratio.

- Most gasoline powered motor vehicles are set up to run slightly rich at sea level. Unless these vehicles are altitude compensating, they will be further enriched as the altitude increases, since there is less oxygen present.

- The amount of leaning is directly proportional to the level of oxygen contained in the fuel. The higher the percent of oxygen in the fuel, the leaner the effective air to fuel ratio will be. As the air to fuel ratio becomes leaner, CO emissions are reduced.

Thus, at Colorado's altitudes, most vehicles run richer than at sea level. This excess fuel results in less complete combustion and thus increased carbon monoxide emissions. Oxygentated fuels counter-act these factors.

Since vehicles are running rich at high altitudes, the enleaning effect of oxygenated fuels is not anticipated to result in vehicle driveability degradation.

Current State law prohibits the Commission from requiring ASTM Reed Vapor Pressure (RVP) standards for ethanol blends. There is no undue concern with the lack of RVP standards on ethanol blends for the following reasons. First, Regulation No. 13 is being proposed as a wintertime only program. Volatility induced vapor lock is primarily a summertime problem. Marketing ethanol blended gasoline during the other eight months of the year would be the decision of individual fuel marketers. Second, data provided by the State Inspector of Oils indicates that the vast majority of gasoline sold in Colorado during 1986 was significantly below the applicable maximum RVP standard. In terms of ethanol blending, this implies the majority of gasoline could have been blended with ethanol and remain within RVP limits. State law C.R.S. 8-20-204, as revised July 1, 1986 is largely responsible for this lower RVP gasoline. The Commission would prefer to have appropriate ASTM RVP standards apply to all final oxygenated fuels but recognizes that the Colorado General Assembly has this prerogative

The Commission encourages and directs the Division to work with non-retail motor fuel suppliers to keep adequate records and inform purchasers of non-retail fuel regarding the amount and type of oxygenate in the fuel supplied to and in the AIR Program area.

The oxygenated fuels program provided in Regulation No. 13 will be in effect for the period of January 1 to March 1 of 1988 and for each period of November 1 to March 1, thereafter. This time period is being used for the following reasons:

- High levels of carbon monoxide are experienced in Denver and Colorado's Front Range during the winter months. For the most part exceedances of the CO standard occur between November 1 and March 1 of each winter.

- There are several environmental, climatic and geographic reasons for these high winter-time concentrations. These include a large motor vehicle fleet, traffic congestion, high altitude, cold weather and atmospheric temperature inversions.

- High CO concentrations in Colorado are brought about in part by Colorado's altitude and cold weather. At higher altitudes and colder temperatures, motor vehicles tend to have less efficient fuel combustion, resulting in increased levels of CO.

- Another cause of high carbon monoxide concentrations is the incidence of winter-time temperature inversions which can develop during the evening. An inversion will trap pollutants such as carbon monoxide near the surface. In these conditions of stagnate air, extremely high concentrations of carbon monoxide build and collect.

If the marketplace for Class A motor fuel operates in an open and competitive manner, a number of oxygenates should be available for use in the AIR Program area which, when blended with a base fuel, will produce oxygenated fuels that meet this regulation. Any attempt to limit the choice of oxygenates available in the AIR Program area between December 1 to March 1 of 1988 and for each period of November 1 to March 1, thereafter, while this regulation is in effect, through a combination, conspiracy, trust, pool, agreement or contract intended to restrain or prevent competition in the supply or price of base fuels suitable for blending with an oxygenate to produce oxygenated fuels which comply with this regulation and applicable EPA requirements, may constitute an illegal restraint of trade in violation of Section 6-4-101, et. seq., Colorado Revised Statutes.

Authority for Regulation No. 13 can be found in the Colorado Air Quality Control Act, Section 25-7-101 et seq., C.R.S. 1982 (1986 Supp.). Specifically, Section 25-7-106(1)(e) authorizes the Colorado Air Quality Control Commission to develop "a control or prohibition respecting the use of a fuel or fuel additives in a motor vehicle to the extent authorized by Section 211(c) of the federal act". Specific authority can also be found in Section 25-7-109(3)(d).

V. FISCAL IMPACT STATEMENT

Proposed Regulation No. 13 would require the use of oxygenated fuels in the AIR Program area starting January 1 1988 to March 1 of 1988, and for each period of November 1 to March 1, thereafter. This regulation would require the use of an oxygenate such as an alcohol or an ether to be blended into gasoline.

The increase in the retail price of gasoline due to this regulation is being estimated at .05¢ to 3.5¢ per gallon. The affected AIR Program (Front Range) area consumes an estimated 1.2 billion gallons of gasoline a year. For the four month winter period oxygenates would be required each year, this would affect an estimated 380 million gallons of gasoline annually. Using the estimated high range of 3.5¢ per gallon increase, this would result in an annual cost of $13.3 million.

Based on Division testing, a 2% fuel economy penalty was seen for closed loop vehicles operating on oxygenated fuels. This is estimated to be 250,000 vehicles in the affected area. Assuming each vehicle is driven 4,000 miles from November 1 to March 1, each vehicle averages 25 mpg, 160 total gallons of gasoline would be consumed per vehicle. A 2% increased fuel consumption would increase consumption an additional 3.2 gallons. This results in a total increase of 800,000 gallons. At one dollar per gallon, this is an additional $800,000. This brings the total program cost to $14.1 million annually.

With both ethanol and MTBE in use in the marketplace, this regulation is estimated to result in a 300 ton per day, or 14% reduction in ambient carbon monoxide levels. This results in a cost of $128 per ton of carbon monoxide reduced.

These figures estimate increases in the retail price of gasoline, and encompass all associated costs to provide oxygenated fuels. Gasoline refiners, blenders, distributors and marketers will all have costs as a result of this regulation. Refiners may have a reduction in crude oil through-put from their refinery operations, as oxygenates will be displacing gasoline. Refiners or fuel blenders will need to purchase and blend an oxygenate into gasoline. This may require additional tankage and blending facilities in some cases. Retail fuel marketers, and private fleets with fueling facilities will need to ensure underground tanks are clean and water free before handling any alcohol blended gasoline. Final filters at the fuel pump nozzles may need to be added when dispensing alcohol blends. These costs are included in the estimates made above regarding cost per gallon increase.

It should be noted that these estimates are using the high end of retail gasoline cost estimates, and are the costs applicable to the fully implemented program, and would be less during the phase-in years. There was conflicting testimony at the public hearing regarding costs. Representatives of the petroleum industry estimated that costs of implementing the program could range up to 8.3 cents per gallon and total $49 million. These cost estimates vary so widely because an oxygenated fuel program in the AIR Program area may encourage the use of such fuels in other areas and states with carbon monoxide problems. Some owners of motor vehicles may also incur repair costs.