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GAO

Report to Congressional Requesters

June 2005

GASOLINE MARKETS

Special Gasoline Blends Reduce Emissions and Improve Air Quality, but Complicate Supply and Contribute to Higher Prices

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GAO-05-421

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Highlights

Highlights of GAO-05-421, a report to congressional requesters

Why GAO Did This Study

The Clean Air Act, as amended, requires some areas with especially poor air quality to use a "special gasoline blend" designed to reduce emissions of volatile organic compounds (VOC) and nitrogen oxides (NOx) and requiring the use of an oxygenate such as ethanol. In less severely polluted areas, the Act allows states, with EPA approval, to require the use of other special blends as part of their effort to meet air quality standards.

GAO agreed to answer the following: (1) To what extent are special gasoline blends used in the United States and how, if at all, is this use expected to change in the future? (2) What effect has the use of these blends had on reducing vehicle emissions and improving overall air quality? (3) What is the effect of these blends on the gasoline supply? (4) How do these blends affect gasoline prices?

What GAO Recommends

GAO is making four recommendations to EPA, including: (1) that the agency, with the Department of Energy and others, develop a plan to balance the environmental benefits of using special fuels with the impacts of these fuels on the gasoline supply infrastructure and (2) if warranted, that EPA work with other agencies to identify what statutory or other changes are required to implement this plan and request those authorities from Congress. EPA declined to comment on the findings and recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-05-421.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells, 202-512-3841 or wellsj@gao.gov.

What GAO Found

Although there is no consensus on the total number of gasoline blends used in the United States, GAO found 11 distinct special blends in use during the summer of 2004. Further, when different octane grades and other factors are considered, there were at least 45 different kinds of gasoline produced in the United States during all of 2004. The 11 special blends GAO found are often used in isolated pockets in metropolitan areas, while surrounding areas use conventional gasoline. The use of special blends may expand because a new federal standard for ozone may induce more states to apply to use them. To date, the Environmental Protection Agency (EPA) has generally approved such applications and does not have authority to deny an application to use a specific special blend as long as that blend meets criteria established in the Clean Air Act. EPA staff told us that there had been recent congressional debate regarding EPA's authority with regard to approving special gasoline blends but that the bills had not passed.

EPA models show that use of special gasoline blends reduces vehicle emissions by varying degrees. California's special blend reduces emissions the most—VOCs by 25-29 percent, NOx by 6 percent compared with conventional gasoline, while also reducing emissions of toxic chemicals. In contrast, the most common special gasoline blend (used largely in the Gulf Coast region) reduces VOCs by 12-16 percent and NOx by less than 1 percent compared with conventional gasoline. The extent of reductions remains uncertain, because they rely, at least in part, on data regarding how special blends affect emissions from older vehicles, and these estimates have not been comprehensively validated for newer vehicles and emissions controls. Regarding air quality, EPA and others have concluded that improvements are, in part, attributable to the use of special blends.

The proliferation of special gasoline blends has put stress on the gasoline supply system and raised costs, affecting operations at refineries, pipelines, and storage terminals. Once produced, different blends must be kept separate throughout shipping and delivery, reducing the capacity of pipelines and storage terminal facilities, which were originally designed to handle fewer products. This reduces efficiency and raises costs. In the past, local supply disruptions could be addressed quickly by bringing fuel from nearby locations; now however, because the use of these fuels are isolated, additional supplies of special blends may be hundreds of miles away.

GAO evaluated pretax wholesale gasoline price data for 100 cities and generally observed that the highest prices tended to be found in cities that use a special gasoline blend that is not widely available in the region, or that is significantly more costly to make than other blends. There is general consensus that increased complexity, and higher costs associated with supplying special blends, contribute to higher gasoline prices either because of more frequent or severe supply disruptions or because higher costs are likely passed on at least in part to consumers.

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Abbreviations

AQIRP	Air Quality Improvement Research Program
CBG	Cleaner Burning Gasoline
CO	carbon monoxide
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FIP	federal implementation plan
MTBE	methyl tertiary-butyl ether
NAAQS	National Ambient Air Quality Standards
NOx	nitrogen oxides
OPIS	Oil Price Information Service
RFG	reformulated gasoline
RVP	reid vapor pressure
SIP	state implementation plan
VOCs	volatile organic compounds

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United States Government Accountability Office
Washington, D.C. 20548

June 17, 2005

The Honorable James Jeffords
Ranking Minority Member
Committee on Environment and Public Works
United States Senate

The Honorable Barbara Boxer
United States Senate

In 2004, consumers in the United States used approximately 140 billion gallons of gasoline, an amount equivalent to approximately 10 percent of the world's total consumption of petroleum products. Despite significant improvements in vehicle emissions and fuel efficiency technology, gasoline use remains a major source of harmful pollutants such as volatile organic compounds (VOC) and nitrogen oxides (NOx), both of which can contribute to formation of ground-level ozone—a pollutant linked to a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis.[1] Vehicle emissions also contribute to smog and acid rain, which can reduce visibility and damage property. The Clean Air Act (the Act), as amended, provides a federal and state framework to address air pollution and its health consequences. Among other things, the Clean Air Act has required improvements in emissions controls on automobiles, power plants, and other significant contributors to pollution. Under the Act, the federal government establishes air quality standards for several pollutants, including ozone and carbon monoxide. States that do not meet these standards must develop plans to improve air quality and submit those plans to the Environmental Protection Agency (EPA) for approval.

In 1990, the Clean Air Act was amended to require some areas with poor air quality to use "special gasoline blends"—blends of gasoline, designed to be cleaner burning. Specifically, the Act requires areas with the worst air quality to use "reformulated" gasoline, a special blend of gasoline designed to reduce emissions of VOCs and NOx. Reformulated gasoline also

[1]Research by EPA and others has shown that high levels of air pollution are correlated with these and other health effects. However, there is insufficient research linking health effects to the use of specific special gasoline blends and, as a result, this report does not address the health effects of special gasoline blends.

includes additives such as ethanol, which reduce emissions of carbon monoxide in some engines—these additives are called "oxygenates" because they increase the oxygen content of the fuel.[2] In less severely polluted areas, the Act gives states the option of using reformulated gasoline or seeking EPA approval to require the use of other special gasoline blends as part of overall efforts to meet federal air quality standards. States applying for EPA approval to require the use of a special gasoline blend must demonstrate that even with the use of all reasonable and practicable options, additional emission reductions are needed to achieve federal air quality standards. States also must demonstrate that no other measures that would bring about timely attainment exist or that existing measures, such as state inspection and maintenance programs, are unreasonable or impracticable. Once EPA has determined that these criteria are met and has approved a state's application to use a special gasoline blend in a given location, that fuel becomes a requirement.

Gasoline is a mixture of multiple components. With the exception of ethanol and some other additives, these components are produced from crude oil through a set of processes collectively known as refining. The types and amounts of components in gasoline can be adjusted for a number of reasons, such as improving engine performance or reducing emissions. As a general matter, special gasoline blends differ from conventional gasoline in at least one of three ways: a reduced tendency to evaporate, the addition of an oxygenate, or reduced levels of one or more chemicals—such as sulfur. In this report, "conventional gasoline" refers to the basic gasoline blend used everywhere that a special gasoline blend (e.g., reformulated gasoline, state special blends, etc.) is not.

Whatever the blend, gasoline used in the United States is provided by some combination of U.S. refineries and/or imports of gasoline or components. Most gasoline produced in the United States is refined in one of four major refining areas located along the East Coast, West Coast, Gulf Coast, and Midwest. From a refining area or coastal terminal, gasoline is shipped through a network of pipelines, water barges, or trucks to large storage terminals, which may have tanks capable of holding hundreds of millions of

[2]There are two oxygenates commonly in use. Methyl tertiary-butyl ether (MTBE) is derived from crude oil and was the most common oxygenate additive until recent years, when it was found to contaminate ground water supplies, and has since been banned in a number of states. In its place, ethanol has increasingly been used as an oxygenate.

gallons of gasoline. From there, it is distributed to retail outlets such as local gasoline stations by large over-the-road tanker trucks.

Over the past several years, gasoline prices in parts of the United States have on several occasions experienced sudden, significant price increases. Some areas with unique gasoline blends, such as California and parts of the Midwest, have been especially hard hit. Some experts have attributed these price increases, in part, to special gasoline blends and have suggested that more uniform national gasoline standards could lead to lower or more stable gasoline prices while meeting air quality goals. Others, including some state governments, believe that special gasoline blends are an important tool that has enabled them to meet federal air quality standards at lower cost than other alternatives.

In this context, we agreed to answer the following questions:

1. To what extent are special gasoline blends used in the United States and how, if at all, is this use expected to change in the future?

2. What have EPA and others determined regarding the role of special gasoline blends in reducing vehicle emissions and improving overall air quality?

3. What is the effect of these blends on the gasoline supply in the United States?

4. How do these blends affect gasoline prices?

In answering these questions, we reviewed federal and state analyses of gasoline markets and the environmental effects of various special gasoline blends; examined the literature on gasoline supplies and prices; and analyzed wholesale gasoline price data for 100 cities and the national average. We interviewed a wide range of government officials and industry experts including federal officials at the EPA and the Department of Energy's Energy Information Administration; staff at state environmental offices; academic and industry experts; petroleum industry officials from companies involved in refining, terminal operations, and pipeline operations, as well as from large oil companies; and representatives of trade associations. We also conducted detailed examinations of markets in California, Louisiana, Texas, and New Jersey—states with large refining sectors and experience with producing and using special gasoline blends. Because many factors may affect gasoline prices at various times, only some of which are readily and consistently observable through available data, we agreed to report on prices and volatility but not to provide a definitive causal link between specific gasoline blends and prices. We conducted our work from June 2004 to May 2005 in accordance with generally accepted government auditing standards. For a more detailed discussion of the scope and methodology of our reiew, see appendix I.

Results in Brief

Although there is no consensus on the total number of special gasoline blends used in the United States, we found that, in addition to conventional gasoline, at least 11 fundamentally distinct special gasoline blends were used during the summer of 2004 in parts of 34 states and covering approximately one-sixth of all the counties in the United States. In the summer of 2001—the last year for which we had data—special gasoline blends accounted for slightly more than half of the total gasoline volume consumed in the United States, with the rest accounted for by conventional gasoline. When different octane grades and other factors are considered, there were at least 45 different blends of gasoline produced and handled by pipelines in the United States during the entirety of 2004. Special gasoline blends are often used in isolated pockets because these blends have generally been adopted in large metropolitan areas in response to severe air quality problems, while surrounding areas have generally continued to use conventional gasoline. Further, EPA's approvals of individual states' applications to adopt special gasoline blends have been made independently over time without consideration of the other fuels already in use in the region. For example, East St. Louis, Illinois, and St. Louis, Missouri (two cities in the same metropolitan area, which straddles two states and two EPA regions) separately applied to EPA and received approval for different gasoline blends. The use of special gasoline blends may continue to expand given that EPA recently finalized a more stringent federal standard for ozone and, as a result, another 138 counties across the United States are now out of compliance with the national air quality standard. To meet the new standard, it is likely that many more locations will apply to use special gasoline blends. To date, EPA has generally approved such applications and does not have authority to deny an application to use a specific special gasoline blend as long as that blend meets the environmental criteria established in the 1990 amendments to the Clean Air Act. EPA staff told us that there had been congressional debate regarding EPA's authority during consideration of recent energy legislation, but that its authority had not changed as of May 2005.

Use of these special gasoline blends reduces vehicle emissions by varying degrees. California's special gasoline blend—the fuel formulated to reduce emissions the most—offers the greatest reductions. Specifically, EPA models how different gasoline blends affect emissions and estimates that California's blend reduces VOCs by 25-29 percent and NOx by about 6 percent compared with conventional gasoline, while also reducing emissions of toxic chemicals and other substances. In contrast, the most commonly used special gasoline blend—one of the least stringent blends and used primarily in the Gulf Coast region—is estimated to reduce VOCs by about 12-16 percent and NOx by less than 1 percent compared with conventional gasoline. The extent of reductions remains unclear, however, because these estimates are based, in part, on data regarding how special gasoline blends affect emissions from older vehicles, and these data have not been comprehensively validated through testing on current vehicle types with newer emissions controls. In the case of oxygenates, there appears to be agreement that the addition of oxygenates reduces emissions from older vehicles. However, improvements in automobile technology in newer vehicles now automatically reduce emissions of carbon monoxide and other pollutants and, for these vehicles, may have negated many of the benefits of adding oxygenates to gasoline. Some studies have also found that use of ethanol can increase emissions of pollutants that can increase ozone levels. Regarding air quality, EPA and other experts have concluded that improvements in air quality seen in some parts of the country are at least partly attributable to the use of special gasoline blends. However, studies on the impact of individual emissions reduction efforts—such as special gasoline blends—are limited and incomplete, in part because of difficulty isolating the effect of gasoline blends from other factors that affect air quality such as weather and emissions from other sources.

The proliferation of special gasoline blends has made it more complicated to supply gasoline and has raised costs, significantly affecting operations at refineries, pipelines, and storage terminals. At refineries, making these blends can require additional investment such as installing new processing equipment and the use of larger amounts of valuable components in the blending process—making it more costly to produce special gasoline blends. Once produced, different blends of gasoline must be kept separate throughout the shipping and delivery process, and the increased number of gasoline blends has reduced the capacity of pipelines and storage terminal facilities, which were originally designed to handle fewer products. For example, several pipeline companies reported that the capacity of their systems has been reduced because they have had to slow the speed of products through the pipelines in order to off-load special blends at specific locations, which raises the average cost of shipping gasoline. Similarly, storage terminals have not been able to fully utilize the volume of their storage tanks because the tanks were designed to handle fewer types of fuel and are often larger in size and fewer in number than necessary for handling smaller batches of special gasoline blends. Further, the proliferation of special blends has, according to several buyers from these wholesale markets, limited the number of suppliers of some of these fuels, posing challenges when traditional supplies are disrupted, such as during a refinery outage or pipeline delay. In the past, local supply disruptions could be addressed relatively quickly by bringing fuel from nearby locations; now, however, additional supplies of special gasoline blends may be hundreds of miles away.

We evaluated pretax, wholesale gasoline price data for 100 cities and generally observed that the highest prices tended to be found in cities that use a special gasoline blend that is not widely available in the region or that costs significantly more to make than other blends. We also found high prices in cities that are far away from major refining areas or other sources of gasoline. For example, of the 100 cities we examined, most of the 20 cities with the highest prices used special blends of gasoline. The other cities with the highest prices used conventional gasoline year-round, but these are long distances from major refining centers or are located on or near a single smaller pipeline. For the period, December 2000 through October 2004, average prices in the 20 highest-price cities were between 14 and 41 cents per gallon higher than in the city with the lowest price. Further, 5 of the 10 cities with the highest average prices were in California, which uses a unique gasoline that only a few refiners outside of the state make and is expensive to refine. In contrast, the lowest prices were typically found in cities that are close to major refining centers or that used gasoline widely available in their region. For example, among the 20 cities with the lowest prices, 8 used conventional gasoline—the most widely available gasoline blend—and 9 used 7.8 reid vapor pressure (RVP) gasoline—the most widely used special blend, largely used in areas close to the Gulf Coast refining center. The other three cities with the lowest prices—Houston, Birmingham, and Atlanta—used less common special blends but are all close to the largest refining area, the Gulf Coast and, therefore, have many more potential supply options than more isolated cities do. In addition, we found that prices tended to be more volatile in cities that used special gasoline blends. Specifically, 18 of the 20 cities with the most volatile prices used special blends of gasoline, while 17 of 20 cities with the lowest volatility used either conventional or 7.8 RVP gasoline.

While prices for special blends tend to be higher than for conventional gasoline, available data did not allow us to attempt to isolate the effects of specific special gasoline blends on gasoline prices or to definitively establish a causal link between specific special blends and price volatility. Specifically, we did not have sufficient data to control for all other potential contributing factors—such as the distance from cities to the sources of gasoline supply, or specific features of these cities that might influence prices regardless of the blend of gasoline used. However, there is a general consensus among the studies we reviewed and the experts we spoke with that the increased complexity, and higher refining, transportation, and storage costs associated with supplying special gasoline blends, have contributed to higher gasoline prices overall and for specific special blends either because of more frequent or severe supply disruptions or because higher costs are likely passed on at least in part to consumers. Moreover, our findings are generally consistent with results of government, academic, and private studies, which found that the gasoline supply system is increasingly stressed and also found isolated pockets of higher and/or more volatile prices in cities that use special gasoline blends that are not widely used.

To provide better information about the emissions and air quality impacts of using special gasoline blends, we recommend that the EPA Administrator direct the agency to comprehensively study how special gasoline blends affect the emissions from the vehicles that comprise today's fleet and use the results of this work to make appropriate modifications to the models that states use to estimate the emissions and air quality benefits of using them. In order to identify how to balance the environmental benefits of using special gasoline blends with the impacts that the use of these fuels have on the supply infrastructure and prices, we are recommending that EPA work with the states, the Department of Energy, and other stakeholders to develop a plan to balance these factors. If warranted by the results of this study, we are further recommending that EPA work with the Department of Energy and others to identify what statutory and other changes are required to achieve this balance and report these to Congress and to request that Congress provide the needed authority to the appropriate federal agency or agencies.

We provided a copy of our draft report to EPA for comment. The agency did not comment on our findings or recommendations but did provide technical comments that we have adopted, as appropriate.

Background

The Clean Air Act, as amended, provides the basic statutory framework for the role of the federal government and the states in managing air quality in the United States. Among other things, the Act authorizes EPA to set and enforce standards, referred to as National Ambient Air Quality Standards (NAAQS), for pollutants. EPA has subsequently set standards for six pollutants—ozone, particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead. While carbon monoxide is directly emitted when various fuels are burned, ground-level ozone is formed when VOCs and NOx mix in the presence of heat and sunlight. As a result, emissions of VOCs and NOx are considered by EPA and the states in their efforts to reduce concentrations of ground-level ozone. Because heat and sunlight act as catalysts in the formation of ground-level ozone, high ozone levels are most prevalent in spring and summer.

EPA sets and enforces the NAAQS to, among other things, reduce the negative health effects of air pollution. Each of the six pollutants covered by the NAAQS is known to cause a variety of adverse health and other consequences. For example, at certain concentrations ground-level ozone and carbon monoxide can, among other things, cause lung damage, eye irritation, asthma attacks, chest pain, nausea, headaches, and premature death. To enforce the standards, EPA evaluates monitoring data on air quality to determine whether local air quality meets federal standards—designating areas as in either attainment (if they meet the federal standards) or nonattainment (if they do not meet the federal standards) with each of the NAAQS.[3]

Under the Act, states that contain areas in nonattainment with the NAAQS are required to identify how they will reduce emissions and improve air quality to meet them. For each pollutant, states are required to prepare a state implementation plan (SIP) and have the plan approved by EPA.[4] States have choices in determining how to reduce emissions and meet air quality standards, determining, among other things, how much to reduce emissions from mobile sources such as automobiles compared with other sources of similar emissions such as power plants. Because use of gasoline

[3]In some cases, such as when air quality data are insufficient, EPA may not be able to designate an area as being in attainment or nonattainment. In these cases, EPA designates the area as “unclassifiable.”

[4]In the event that a state does not develop an EPA-approved SIP, EPA may develop a federal implementation plan (FIP).

in automobiles emits several chemicals, including carbon monoxide, nitrogen oxides, and VOCs, and because emissions from automobiles are often an important contributor to local air quality problems, the federal government and the states often focus on reducing automobile emissions. Whatever the planned reductions, states must identify an inventory of air emissions and demonstrate in their SIPs how they will achieve attainment in a specific time frame. States typically demonstrate this through modeling analysis that estimates how the various efforts in their SIPs will reduce emissions and improve air quality.

The Act also provides authority to set standards and establish requirements for some programs specifically designed to reduce vehicle emissions. For example, using authority provided under the Act, EPA has required newer cars to meet more stringent emissions standards, and vehicle manufacturers have incorporated emissions-control devices such as catalytic converters and oxygen sensors to meet them. Further, the Act requires cars to have under-the-hood systems and dashboard warning lights that check whether emissions control devices are working properly. In addition, the Act requires that some areas—generally highly populated metropolitan areas—have programs for periodic inspection and maintenance of vehicles. These programs identify high-emitting vehicles, which sometimes have malfunctioning emissions control devices, and require vehicle owners to make repairs before the vehicles can be registered.

Federal and State Actions Regulate Gasoline

The Act gives the federal government, through the EPA, primary authority for regulating the environmental impacts of gasoline use.[5] For example, the Act sets minimum national standards for conventional gasoline, as well as requiring that certain gasoline blends formulated to reduce emissions be used in some areas with especially poor air quality. Specifically, for certain areas with long-standing and especially poor air quality, the federal government requires the use of special reformulated gasoline, commonly referred to as RFG. The amendments also require other areas to use special

[5]Before 1990, fuel requirements were much simpler, with only limits on volatility in the summer months to control ozone formation. The state of California chose to more stringently regulate gasoline formulations before the federal government. Because California regulated gasoline formulations prior to the specific authority provided to the EPA, California may continue to require more stringent fuel formulation requirements without EPA approval, but must at least meet (or exceed) the other federal requirements.

gasoline blends designed to reduce summertime ozone pollution and wintertime carbon monoxide pollution.

The Act allows states or regions not required to use RFG to seek EPA approval to require use of other special gasoline blends to aid in improving air quality, provided that they do not violate minimum federal standards. In 2001, EPA studied the proliferation of gasoline blends and reported that several states had chosen special blends other than RFG for one or more of three reasons: (1) the states were not eligible to require RFG because their air quality was not bad enough, (2) the states wanted to avoid the RFG requirement to use an oxygenate and its added cost, (3) fuel suppliers and states believed that the other special blend would be less costly than RFG while meeting their need to reduce emissions. States seeking to use a special gasoline blend must obtain formal approval from EPA, generally the regional office with authority to review their SIPs. Specifically, under the Clean Air Act, section 211(c)(4)(C), EPA may approve applications by states to use special gasoline blends if the states demonstrate that the fuel is needed to reach attainment with federal air quality standards.

In guidance issued in August 1997—after several of the special gasoline blends were approved—EPA clarified that they can approve a state gasoline requirement only if "no other measures that would bring about timely attainment exist," or if other measures are "unreasonable or impracticable." The guidance requires that states do four things in their application for approval of a new or revised SIP: (1) quantify the estimated emissions reductions required to reach attainment with the federal NAAQS for ozone; (2) identify possible control measures that could be used in place of special gasoline blends and provide emissions reduction estimates for those measures; (3) explain why those measures are "unreasonable or impracticable"; and (4) show that, even with use of all "reasonable and practicable" measures, additional emissions reductions are needed. As is the case with other new or revised SIPs, these applications are open for public comment, and EPA must consider those comments before making a decision. Once approved, states' special gasoline blends become federally enforceable requirements.

Under some circumstances, EPA may temporarily waive special gasoline blend requirements, referred to as granting enforcement discretion, if, for example, the required special gasoline blend is not available due to a supply disruption. Over the past several years, EPA has waived the requirement to use these special gasoline blends on several occasions when it determined that overall supplies might become tight. We found that

EPA has granted enforcement discretion on at least 23 occasions, allowing gasoline that did not comply with local requirements to be sold there. The causes of these supply disruptions included the 2003 blackout in the Northeast, the series of hurricanes in Florida and the Gulf Coast in 2004, as well as refinery fires, pipeline breaks, and other infrastructure problems. Although there was one short waiver that applied nationwide following the terrorist attacks of September 11, 2001, several of the other waivers were provided to local areas with particularly stringent gasoline formulations including St. Louis, Chicago/Milwaukee, Atlanta, Las Vegas, and Phoenix when there were supply shortages in these areas.

All Gasoline Is a Blended Mix of Components Derived Primarily from Crude Oil

All gasoline is a blend of different components that are predominantly produced in refineries. The simplest refineries primarily separate the components already present in crude oil. More complex refineries also have the ability to chemically change less valuable components of crude oil into more valuable ones. Because of their ability to chemically alter components, complex refineries can increase the amount of gasoline yielded from a given amount of crude oil and reduce the amount of less valuable products. Although most refineries can process many types of crude oil, refineries are generally configured to run most efficiently when refining a specific type of crude oil into a specific group of products.

Absent specific regulatory requirements, refiners blend several components derived from crude oil to produce a gasoline that achieves acceptable engine performance at the lowest cost. Two key aspects of gasoline affect engine performance:

- *Reid vapor pressure* is a measure of gasoline’s tendency to evaporate and also reflects the ease with which it ignites when the spark plug fires in a cold engine. To maintain engine performance, RVP must vary by season and region. Higher RVP is required in colder climates and seasons to allow an engine to start.

- *Octane number* is a measurement of gasoline’s tendency to ignite without a spark, commonly known as “knocking” in a running engine. Some high-performance and other vehicles require gasoline with a higher octane number. To satisfy these requirements and consumer demand, retailers in the United States typically sell three different octane grades of gasoline.

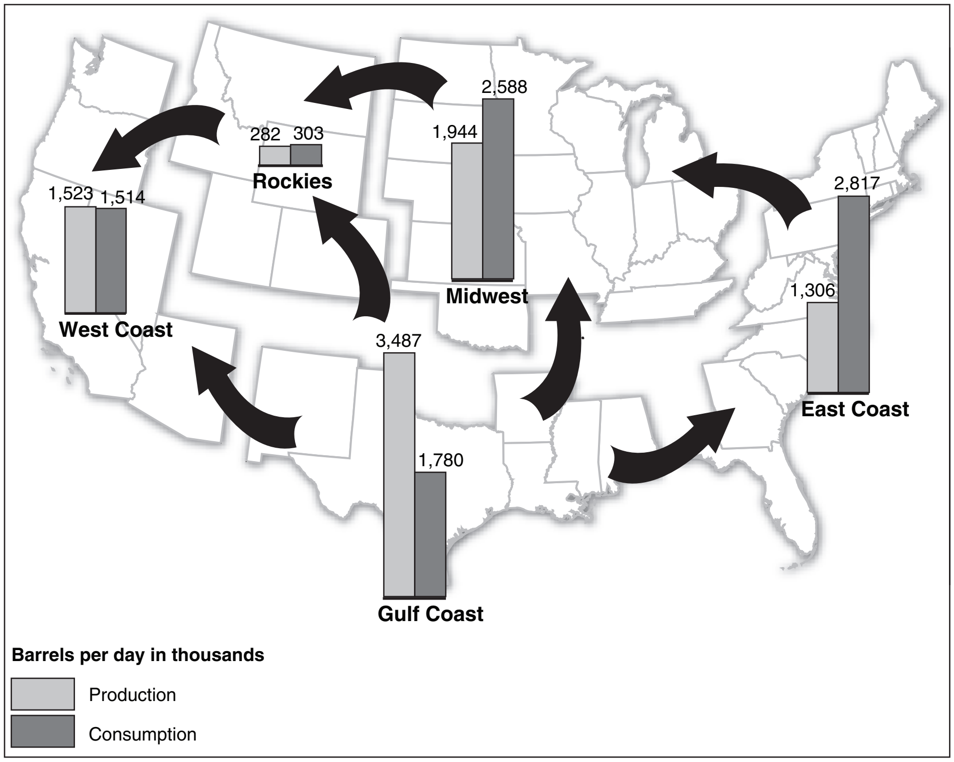
Special gasoline blends developed to reduce pollution are generally adjusted in at least one of the following ways:

- RVP is reduced during the summertime to reduce VOC emissions. Reducing the RVP of gasoline requires reducing the amount of very light compounds, such as butanes and pentanes, blended into the gasoline.
- Toxics, their precursors, or other chemicals are limited so they are not released into the air when the gasoline is burned. Some of these, such as sulfur, naturally occur in crude oil while others, such as benzene, result from gasoline refining.
- Oxygenates, chemical compounds containing oxygen to aide in combustion, are added to gasoline to improve environmental performance when the gasoline is burned, including reducing carbon monoxide (CO) emissions. The most commonly used oxygenates are MTBE and ethanol. Several states have banned MTBE as a result of concerns about groundwater pollution and have switched to using ethanol as an oxygenate where required.

Gasoline Is Moved from Refineries to Consumers through a Complex, Shared Distribution System

Gasoline is shipped from U.S. refineries to consumers by some combination of pipelines, water barges, rail, and trucks to retail gasoline stations. Most of the country's refining capacity is located in the Gulf Coast, West Coast, East Coast, or Midwest with only a small amount in the Rocky Mountain states. As shown in figure 1, the Gulf Coast region supplies gasoline to all the other regions—of these, the Midwest and the East Coast are the most dependent on gasoline from the Gulf Coast. The East and West Coast markets have also imported gasoline from other parts of the world such as Canada, Europe, and the Caribbean.

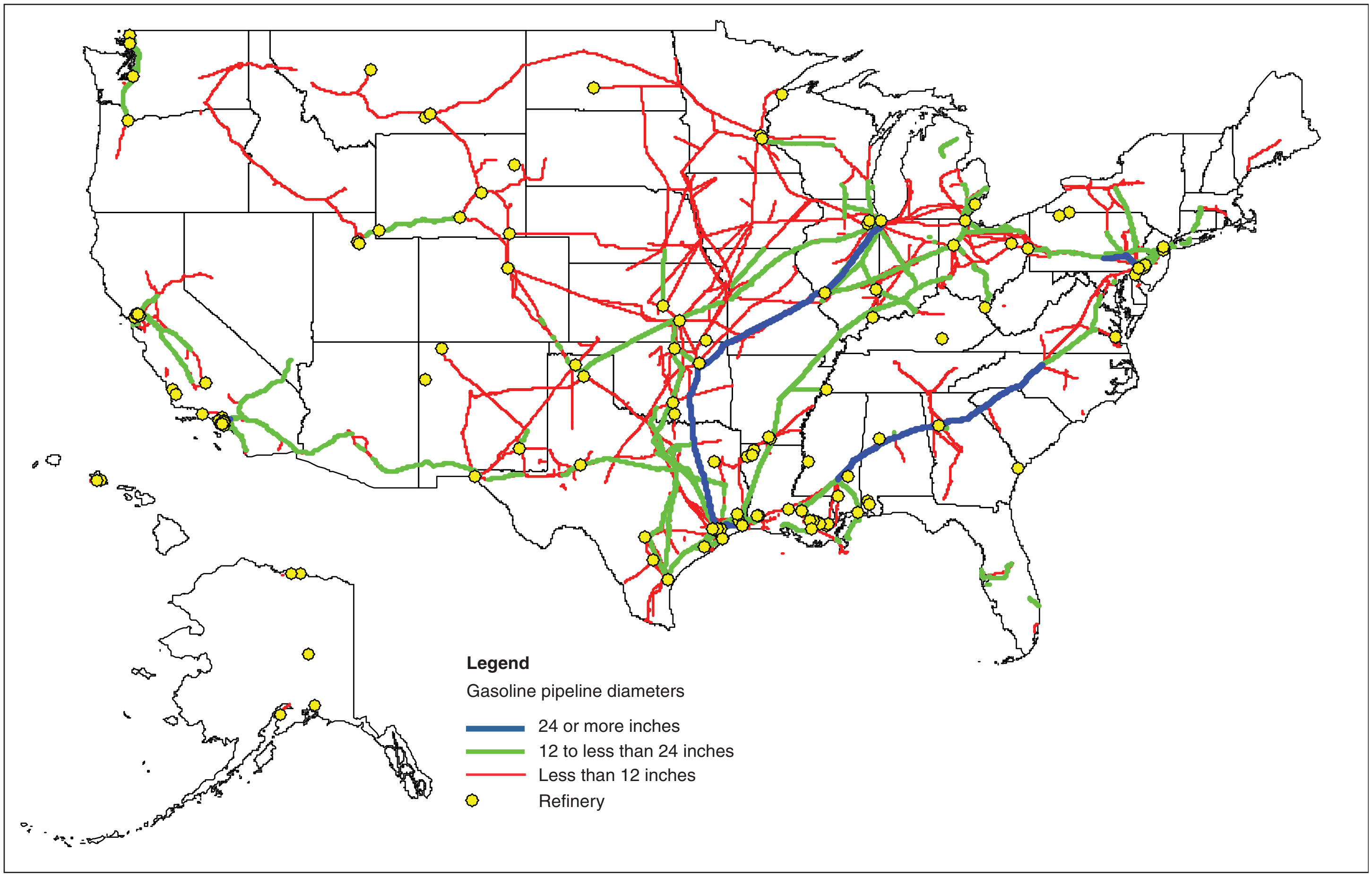
Figure 1: Gasoline Supply and Demand, September 2004



Source: GAO analysis of EIA data.

Several large pipelines travel inland from refineries in the Gulf Coast, East Coast, and West Coast, connecting these key supply centers to areas where gasoline is used. In general, these large pipelines provide the cheapest method for transporting large volumes of gasoline, and pipelines account for more than half of the gasoline shipments in the United States. Several of the major U.S. pipeline systems, such as the ones serving the Midwest and the East Coast, deliver gasoline and other fuels used in multiple states. Figure 2 shows the pipeline system and the major refineries in the continental United States. The largest concentration of pipeline capacity links the Gulf Coast refining region to the large consumer markets in the Midwest and East Coast, while fewer and smaller pipelines connect refining regions to the more sparsely populated states in the Rockies and parts of the West Coast region.

Figure 2: Map of Key Pipelines and Refineries, 2004



Sources: GAO analysis of Department of Transportation and the Energy Information Administration data.

At various points between refining and final retail consumption, gasoline is stored in large tanks, some holding hundreds of millions of gallons of fuel. In many cases, gasoline is stored in tanks at the refinery itself while awaiting shipping. In other cases, fuel is stored at terminal stations located along the pipeline that generally include multiple large tanks. A terminal station serves as a storage facility for gasoline and other petroleum products at places throughout the petroleum refining and transportation process. Some terminals are affiliated with pipelines and used as part of pipeline operations, such as for withdrawals or when pipelines converge. Other terminals are used to allow gasoline and other products to be loaded or off-loaded from barges or tankers. Still other terminals are used to hold gasoline before it is distributed, generally by trucks, to retail gasoline stations. In all of these locations, different gasoline blends must be stored separately, with only one fuel per tank at any given time.

Ethanol that is added to gasoline cannot be shipped in pipelines with other petroleum products because of ethanol's tendency to absorb water. Instead, ethanol is shipped primarily by rail or trucks to terminal stations where it is "splash" blended—mixed in specific proportions as the fuel is added to the storage tank or tanker truck. The federal government and some states have considered requiring or expanding the use of ethanol to reduce consumption of oil and increase demand for agricultural products used to produce it, such as corn.

Special Gasoline Blends Are Widely Used and Use May Increase in the Future

There were 12 distinct gasoline blends in use in the United States during the summer of 2004: 11 special gasoline blends and the conventional gasoline used everywhere a special blend is not used. When different grades of gasoline, special blends used in winter, and other factors are considered, the number of gasoline blends rises to at least 45. New ozone standards and other factors may further increase the number or the use of special gasoline blends in the future, in part because EPA must approve any state's application to require use of a special gasoline blend as long as the proposed fuel meets EPA's environmental standards.

Eleven Special Summer Gasoline Blends Were Used Mostly in Large Cities Creating Isolated Markets

Eleven special gasoline blends were used in the United States during the summer of 2004 in addition to conventional gasoline. The use of special gasoline blends is most prominent during the summer because special fuels are used predominantly to reduce summer ozone levels, and gasoline use is generally the highest during the summer. The requirement to use these fuels requires that all the fuel sold at terminals meet certain specifications at a certain date, which generally requires terminal operators to draw down their inventory of non-summer fuels in advance of filling their tanks with summer fuels. Special gasoline blends are primarily used in highly populated urban areas, and 34 states use a special gasoline blend in one or more areas. The 11 special gasoline blends in use during the summer of 2004 fell into the following categories:

- Three different types of RFG used year-round, the federally required fuel used in areas with the worst air quality. RFG has very low RVP; reduced levels of benzene and other toxics; and contains an oxygenate. The type of RFG blend depends on the area of the country where the gasoline is used and the oxygenate selected. These blends are identified in figure 3 as “RFG North,” “RFG North with ethanol,” and “RFG South.”

- Two types of California Cleaner Burning Gasoline (CBG) used year-round, also referred to as CARB. California CBG is formulated to meet the most stringent gasoline standard in the United States, including very low RVP and reduced levels of sulfur, benzene, and other chemicals. In general, the state of California does not require the addition of an oxygenate in areas not subject to federal RFG standards—identified in figure 3 as “CA CBG.” Gasoline sold in areas also subject to the federal RFG standard must contain an oxygenate, identified as “RFG/CA CBG.”

- In the summer, Arizona allows the use of either a gasoline blend very similar to RFG or a blend similar to CBG. The blend required in Arizona is identified as “AZ CBG.”

- Three summer blends with various reductions in RVP. The federal government requires some areas to use 7.8 RVP gasoline[6] and, in other areas, states have mandated the use of this blend. The other two low-RVP blends are state requirements. These blends are identified in figure 3 as “7.8 RVP,” “7.2 RVP,” and “7.0 RVP.”

- One blend with reduced RVP and reduced sulfur content. The state of Georgia requires this blend for use in the Atlanta area, and it is identified in figure 3 as “7.0 RVP, 30 ppm sulfur.”

- One blend of conventional gasoline with a minimum of 10 percent ethanol by volume, used year-round. The state of Minnesota requires this blend, which is identified in figure 3 as “Ethanol Mandate.”

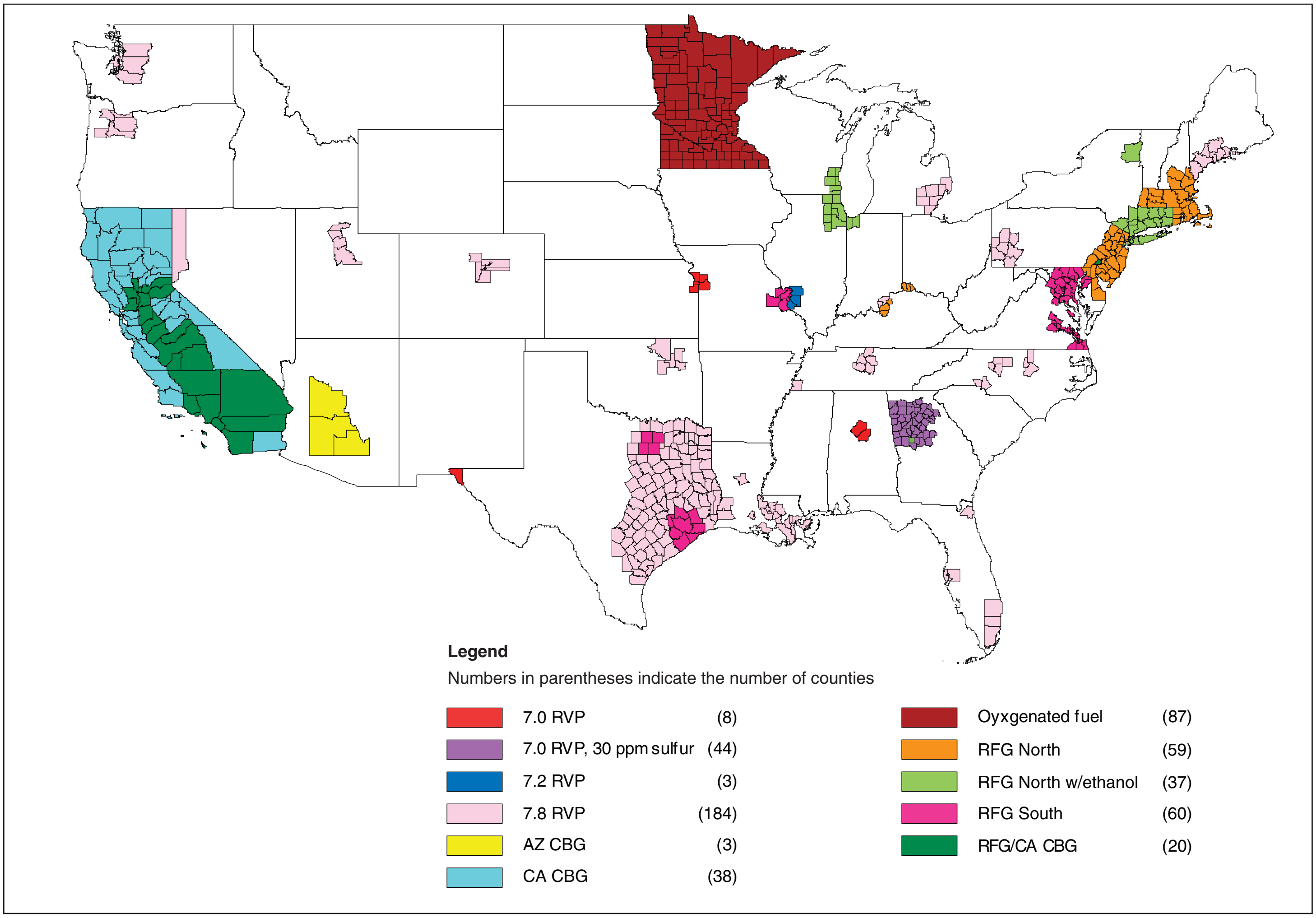
As figure 3 shows, many areas using special gasoline blends are surrounded by regions that use conventional gasoline. In some cases, these areas are relatively large, as is the case for the state of California, where nearly all of the state uses the same fuel—RFG/CA CBG. In other cases, “islands” of special gasoline use can divide otherwise regional gasoline markets. For example, the St. Louis metropolitan area, which includes parts of two

[6] RVP values throughout this report are measured in pounds per square inch at 100ºF, the standard industry measure.

states[7]—Missouri and Illinois—uses three different fuels: one special gasoline blend required on the Missouri side, a different special gasoline blend required on the Illinois side, and conventional gasoline is allowed in the surrounding area. In some cases, special gasoline blends are used in only one area of the country. For example, California CBG, Arizona CBG, and the special blend used in Atlanta, Georgia, are not used anywhere else in the United States. Even relatively common special gasoline blends can create isolated markets if they are not used in nearby areas. For example, although 7.8 RVP is a relatively widely used blend, Pittsburgh, Pennsylvania, is the only city in its region that uses it. Similarly, the Chicago/Milwaukee area uses RFG North with ethanol, a gasoline blend used in the Northeast but not used elsewhere in the Midwest.

[7]Each state is overseen by a separate EPA regional office; Missouri is overseen by EPA region 7 and Illinois is overseen by EPA region 5.

Figure 3: Special Gasoline Blends—Summer 2004

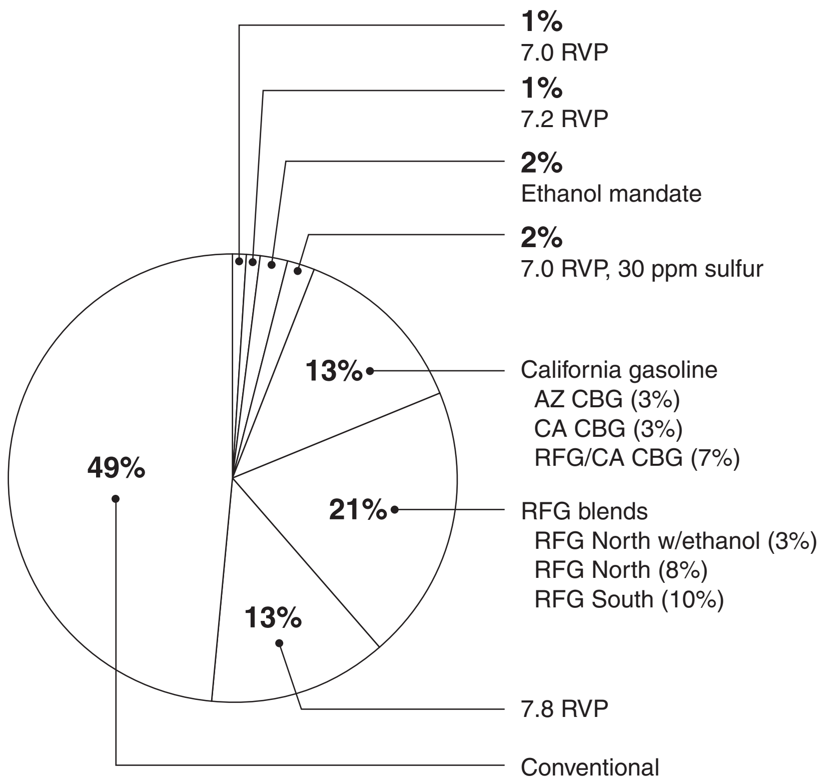


Sources: GAO analysis of EPA, ExxonMobil, the Oil Price information Service, and state environmental agencies' data.

Note: Unshaded areas (shown in white) are areas where conventional gasoline is used.

Special gasoline blends accounted for more than half the gasoline consumed in the United States during the summer of 2001—the last year for which we had complete data. Figure 4 shows the relative consumption of the different gasoline blends then in use. Of the special fuel blends, RFG and 7.8 RVP blends together accounted for about 33 percent of the national gasoline market. California CBG and Arizona gasoline blends accounted for roughly 13 percent of total U.S. gasoline consumption. The remaining 6 percent of gasoline use was divided among four separate blends.

Figure 4: Market Shares for the Various Gasoline Blends Used in 2001



Source: GAO analysis of EPA data.

Other Factors Raise the Number of Gasoline Blends Carried by Pipelines and Other Means to at Least 45

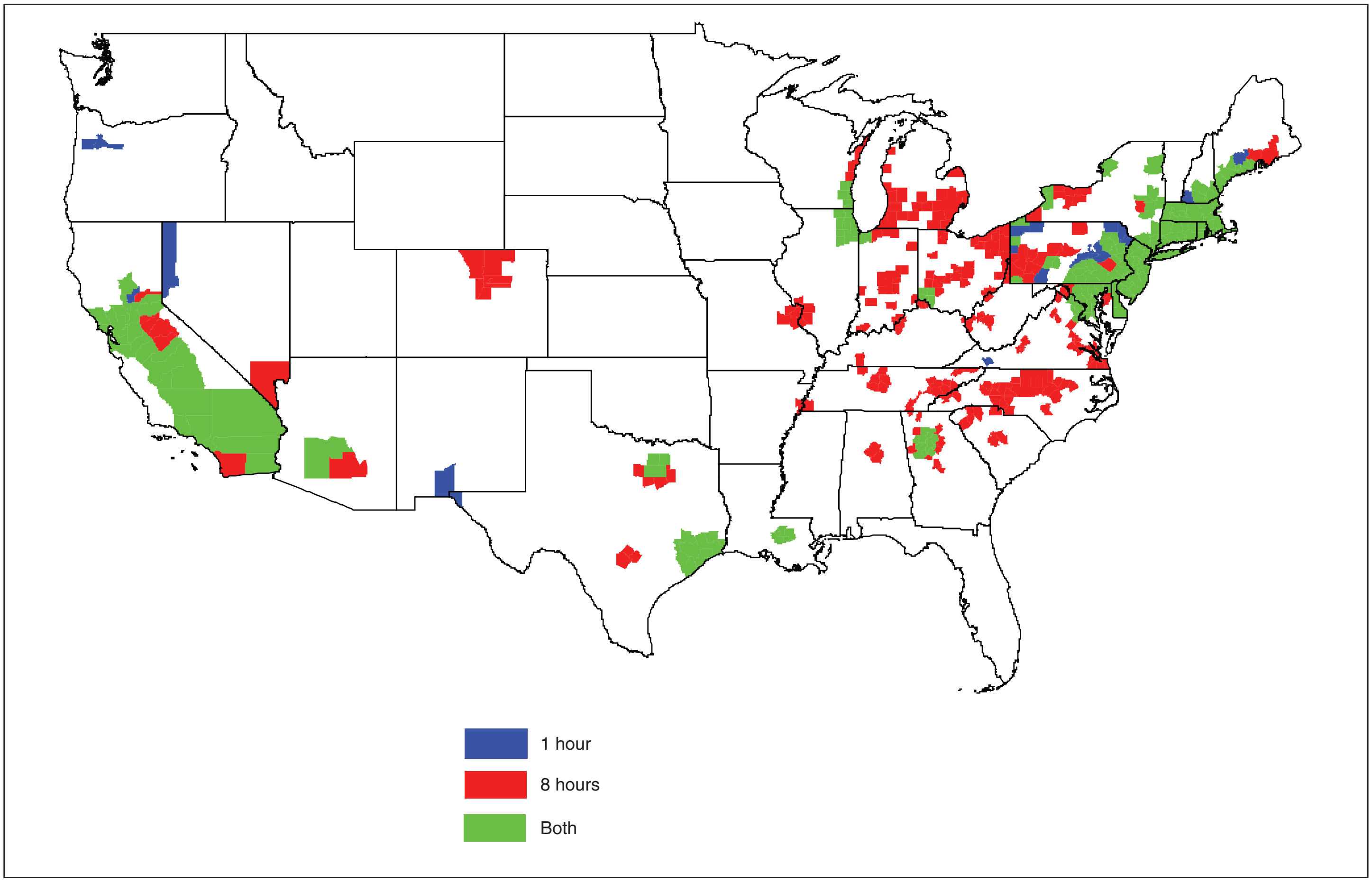
While we have reported that there are 11 special blends used or handled during the summer of 2004, additional factors increase the total number of gasoline blends sold in the United States throughout the year to at least 45. First, although this report focuses on summer gasoline blends, at least 3 special winter-only gasoline blends are required to be used in areas of eight states. Use of these fuels requires that fuel terminals in these areas transition from the fuel that they use in the non-winter season to the required winter fuel. These blends contain an oxygenate to address winter carbon monoxide pollution. Second, because of consumer demand, many gasoline stations sell gasoline in three octane grades—both premium and regular grades are refined and shipped to terminals, where they are blended together to make a midgrade gasoline. Therefore, each gasoline blend is effectively two fuels from the perspective of pipelines and terminals. As a result, pipelines, fuel terminals, and retail gasoline stations carry multiple variations of the gasoline blends previously discussed. Third, gasoline blends differ regionally and seasonally because differences in outside temperatures require different blends to maintain vehicle performance. The primary difference among these blends is RVP. Refiners produce gasoline with higher RVP in cold conditions to allow cars to start and gasoline with lower RVP during warm conditions to improve vehicle operation, even in areas that use conventional gasoline. As a result of these differences, refiners routinely ship different fuels to different regions and also ship different gasoline blends seasonally, but special blends tend to compound these variations. One official with a major petroleum company reported that there were at least 45 different grades of gasoline used in the United States.

New Ozone Standard and Other Factors May Further Increase the Number and/or Use of Special Gasoline Blends

A new ozone standard and deteriorating air quality may lead to an increased number of special gasoline blends and/or more use of these blends in the future. In 2004, EPA issued a final rule implementing a new, more stringent federal air quality standard for ozone that led to the identification of 138 additional counties in nonattainment or maintenance as seen in figure 5.[8] EPA officials that we spoke with did not have any indications that states were planning to submit applications to use special blends in these areas but acknowledged that gasoline is viewed as an effective emissions control strategy and said that they expect some states to consider doing so. Oil company officials told us that officials from some states had approached them to discuss using special gasoline blends. Because states must begin preparing SIPs for the recently designated nonattainment areas, and because several of those states already have chosen to use special gasoline blends, it appears likely that states may seek approval to use such blends in more areas.

[8]The new standard measures ozone levels averaged over 8 hours, while the prior standard measures these levels over 1 hour.

Figure 5: Map of Areas Not Meeting New 8-Hour and Former 1-Hour Ozone Standard, 2004



Source: GAO analysis of EPA data.

Several other factors could also affect the number or use of special gasoline blends. State MTBE bans could force more areas of the country to shift from their current blend to an ethanol blend. In June 2004, EPA identified 19 states that had bans on the use of MTBE either in place or scheduled to phase in, though some of these states did not use MTBE.[9] Worsening air quality in areas such as Atlanta and Baton Rouge may require the gasoline used in these cities to shift from a special blend to RFG, reducing the number of fuels.[10] In addition, a new federal standard for all gasoline—including special blends—that mandates reduced sulfur, promises to improve the effectiveness of catalytic converters already present in most vehicles and could aid some areas in meeting federal air quality standards, potentially reducing the need for these fuels in some areas.

EPA Lacks Authority to Deny Requests to Use Special Gasoline Blends Due to Effects on Supply

During the course of our work, staff from EPA's Office of the General Counsel stated that EPA could not deny an application to require the use of a special gasoline blend that addressed the four elements outlined in EPA's 1997 guidance. They explained that EPA's determinations often deferred to states' evaluations in their applications that, under the Clean Air Act, section 211 (c)(4)(C), no other measures that would bring about timely attainment exist, or that existing measures, such as vehicle inspection and maintenance programs, are unreasonable or impracticable. Further, staff with EPA's Office of the General Counsel staff told us EPA could not reject an application on the basis of the potential impacts on gasoline supply or other regional effects on the gasoline market because such a rejection would be outside of EPA's current authority. Several of the special fuels in use during 2004 were approved prior to the issuance of the 1997 guidance, and EPA officials reported that a variety of standards were used to evaluate applications.

EPA's most recent effort to examine special gasoline blends is consistent with EPA's view that the agency does not have authority to reject a state's application based on regional supply impacts or costs. In 2001, EPA released a staff white paper, in response to a presidential directive, examining whether there were options to maintain or improve environmental benefits while also improving the supply of fuels, such as

[9]These states are, with phase-in year in parentheses, California (2003), Colorado (2002), Connecticut (2000), Illinois (2004), Indiana (2004), Iowa (2000), Kansas (2004), Kentucky (2006), Maine (2007), Michigan (2003), Minnesota (2000), Missouri (2005), Nebraska (2000), New Hampshire (2007), New York (2004), Ohio (2005), South Dakota (2001), Washington (2004), and Wisconsin (2004).

[10]EPA determined that these cities are required to use RFG; however, the states sued, and the lawsuit was in the courts as of April 2005.

gasoline.[11] In that report, EPA examined a number of options to reduce the number of fuels available for states to choose from—similar to a gasoline menu. That report concluded that these options were beyond EPA's statutory authority and would require legislative action to implement.[12] The white paper also noted that it represented a first step in EPA's response to the directive, but that significant additional analysis and study were required. EPA staff told us that there had been congressional debate regarding EPA's authority during consideration of recent energy legislation, but that its authority had not changed as of May 2005.[13] In the study, EPA identified a number of changes that it would make to ease the seasonal transition between gasoline blends used during different parts of the year. Staff also said that little, if any, additional work had been done since the 2001 study, in part because of EPA's lack of authority to implement some of the actions outlined in the study.

Special Gasoline Blends Reduce Emissions and Contribute to Improved Air Quality

Special gasoline blends reduce emissions—particularly those involved in the formation of harmful ground-level ozone—by varying degrees, depending on the blend. The extent of reductions remains unclear, however, because the estimates have not been comprehensively validated through testing on current vehicles and emissions controls. According to EPA and others, these special gasoline blends have contributed to improvements in air quality seen in some parts of the country. The extent of their contribution to improvements relative to that of other contributing factors, such as reductions in power plant emissions, is somewhat uncertain because of the difficulties in isolating the effects of individual emissions reduction efforts, such as special gasoline blends, from other factors that may affect air quality.

[11]The directive was issued as part of the President's National Energy Policy Report issued on May 17, 2001.

[12]According to EPA staff, Congress considered providing additional authority in legislation after the release of this report; however, those bills did not pass. As of April 2005, new legislation passed by the House of Representatives, but not yet passed by the Senate, would limit the number of gasoline blends, but this bill has not yet become law.

[13]In April 2005, the U.S. House of Representatives passed a bill, H.R. 6, which, among other things, limited the expansion of special gasoline blends and requires EPA and DOE to examine the issue and present options to Congress. As of May 2005, no comparable bill had passed the Senate.

Special Gasoline Blends Reduce Emissions, but the Extent of Reduction Remains Uncertain

Over the past 15 years, a wide range of studies by EPA and others have concluded that changes to the properties of gasoline can substantially reduce emissions from automobiles. For example, in 1996, EPA concluded that RFG and low-RVP blends can both significantly reduce VOCs but that RFG offers greater promise in reducing NOx, CO, and toxics. The Air Quality Improvement Research Program (AQIRP), funded by the auto and oil industries, analyzed gasoline properties in detail and comprehensively tested a variety of gasoline blends in a range of vehicles between 1989 and 1992. This effort produced data regarding how the use of various gasoline blends affect emissions from then-current vehicles and concluded that changing certain properties of gasoline, in particular reducing RVP and sulfur, was effective in reducing emissions of pollutants such as NOx, CO, and also hydrocarbons such as unburned fuel. According to EPA officials, using special gasoline blends is attractive to states because the blends can offer immediate emissions reductions from vehicles already on the road.

EPA and others have used the results of these studies to develop models that provide detailed emissions estimates for several of the special gasoline blends currently in use. These models have been used by states in their SIPs to estimate the expected emissions from requiring the use of special gasoline blends instead of conventional gasoline.[14] As shown in table 1, the models estimate that special gasoline blends reduce emissions by varying degrees. California's gasoline—the blend formulated to reduce emissions the most—is estimated to provide the greatest level of emissions reductions, about 25-29 percent for VOCs and about 5.7 percent for NOx. RFG is estimated to provide about the same level of VOC reduction, a lower NOx reduction of about 0.7 percent, but also a 10-20 percent reduction in CO. The special gasoline blend most commonly used in areas not using conventional gasoline—gasoline with an RVP of 7.8—is estimated to reduce VOC emissions by 12-16 percent and NOx by about 0.7 percent. In addition to the pollutants listed in table 1, RFG and California's cleaner burning gasoline also reduces emissions of some toxics such as benzene.

[14]Excluding California, which uses the Motor Vehicle Emissions Inventory.

Table 1: Projected Emissions Reductions Resulting from Low-RVP, RFG, and CBG Gasoline Blends

Gasoline blend	Estimated emissions reductions[a]		
	VOC	NOx	CO
Low RVP			
7.8	12 to 16%	0.7%	No effect
7.2	19 to 23%	0.7%	No effect
7.0	21 to 25%	0.7%	No effect
RFG			
Federal RFG	25 to 29%	0.7%	10 to 20%
California CBG[b]	25 to 29%	5.7%	Not estimated

Source: GAO analysis of EPA data.

[a]Emissions reductions are based on reductions from conventional 9.0 RVP gasoline projected to be in use in calendar year 2006.

[b]EPA estimated VOC and NOx emissions reductions for California CBG and RFG CA/CBG (which includes an oxygenate) were the same for these pollutants; however, RFG CA/CBG would likely provide some reduction of CO, in addition.

However, the extent of emissions reductions associated with various gasoline blends remains somewhat uncertain. GAO,[15] the National Research Council, and others have identified concerns about the overall accuracy of emissions estimates. EPA has addressed some of the concerns about emissions estimates. In one effort to address concerns about the validity of emissions estimates, EPA sponsored a study that compared emissions estimates to measured emission data obtained between 1992 and 2001. The study looked at pollutant concentration data from tunnels and vehicle exhaust data collected from vehicles on roadways using special remote sensing devices at a limited number of sites using a limited range of gasoline blends. As a result, EPA found that the observed emissions data conflicted with emissions estimates; in some cases the testing data were higher than predicted, while in other cases it was lower.

Despite this effort, EPA has not comprehensively studied how various gasoline blends affect vehicle emissions since the early 1990s—when the AQIRP comprehensively tested a variety of gasoline blends in a range of vehicles. Since then, there have been advances in emissions control

[15]GAO, *Air Pollution: Limitations of EPA's Motor Vehicle Emissions Model and Plans to Address Them*, GAO/RCED-97-210 (Washington, D.C.: Sept. 15, 1997).

technology. Consequently, to the extent that emissions from vehicles with newer emissions control technology differ from those of older vehicles, emission estimates may become less certain, especially as vehicles with the newer technology compose a growing portion of the U.S. fleet. EPA officials acknowledge that their efforts since the early 1990s to validate emissions estimates have not allowed them to fully validate how special fuel blends operate in a full range of vehicles of varying vintages and designs over their operating lifetimes. EPA officials told us that they believe such a detailed analysis would improve their understanding of how special gasoline blends affect emissions, but said that they have not had sufficient budgetary resources to collect the needed data to support such an analysis.

In addition to these broad concerns, there is also controversy over the emissions benefits associated with special blends containing oxygenates, which were initially added to gasoline to reduce the emissions of carbon monoxide and other pollutants. However, although there appears to be agreement that oxygenated fuels help reduce emissions of CO from older vehicles, recent studies indicate that the emissions benefits for newer vehicles are questionable. For example, AQIRP, the National Science and Technology Council, and others have reported that improvements in emissions controls on newer vehicles, such as oxygen sensors and computer-controlled emissions systems, may now automatically reduce emissions of CO and other pollutants and may negate many benefits of adding oxygenates. Further, some experts have concluded that adding oxygenates to gasoline may increase emissions of NOx and VOCs and may contribute to increased levels of ozone. As a result, some states, including California, New York, and Georgia have requested waivers from EPA to allow them to use fuel that does not contain an oxygenate. The state of California stipulated in its waiver application that its fuel reduces emissions to a greater extent than federal RFG and that the oxygenate requirement has impeded its efforts to reduce ozone. To date, EPA has not granted any of these waivers. Recently, Congress and others have considered expanding the use of ethanol in gasoline for other reasons, including to benefit U.S. farmers and to reduce the country's reliance on foreign oil.

Reduced Vehicle Emissions Have Led to Air Quality Improvements, but the Extent of Benefits Attributable to Special Gasoline Blends Is Uncertain

EPA and other experts have concluded that improvements in air quality in some parts of the country are at least partly attributable to the use of special gasoline blends. In 2004, EPA reported that ground-level ozone has decreased over the past 10 to 25 years and that these reductions resulted, at least in part, from emissions control programs that include requirements to use special gasoline blends. Further, EPA and other experts concluded that special gasoline blends, such as RFG and low-RVP blends, are effective strategies for states to use to reduce ozone pollution. In addition, a research effort funded by AQIRP found that reducing RVP decreased peak ozone in several cities and would continue to provide benefits for years to come. In addition, the National Research Council reviewed EPA data and found that average ozone levels dropped by about 1 percent coincident with reduced emissions of VOCs, NOx, and CO from on-road vehicles, which fell by 31 percent, 2 percent, and 20 percent, respectively. Based on these and other data, the National Research Council concluded that improvement in air quality is likely attributable, at least in part, to recent improvements in gasoline properties.[16]

Despite the conclusions that special gasoline blends have contributed to improved air quality, findings specifically linking air quality improvement to the use of special gasoline blends are limited and incomplete because of the inherent difficulties in isolating the effects of special gasoline blends from other efforts to improve air quality. Studies examining the effect of special gasoline blends on air quality noted that attributing a change in ozone levels to the use of a special gasoline blend would be difficult.[17] In particular, experts from EPA, the National Science and Technology Council,[18] and the National Research Council have determined that relating trends in the levels of ground-level ozone to trends in emissions and to emissions-control policies can be challenging because of the confounding effects of other variables, including the effects of other control efforts and

[16]Other possible reasons for the improvements include the advent of more stringent standards for vehicles that gradually replace old vehicles built to more lenient standards than current models; and maturation of new-vehicle emissions-control hardware and software as field experience accumulated.

[17]David Stikkers, "A Retrospective Study of Reformulated Gasoline Use in Chicago," *Environmental Informatics Archives.* 1 (2003): 282-294.

[18]The National Science and Technology Council is composed of representatives from several federal agencies charged with coordinating science and technology policies across the federal government.

meteorological fluctuations. For example, the National Research Council noted that since the 1990s—when special gasoline blends became widely used—several other efforts to reduce emissions from vehicles have been made that could also explain changes in air quality, such as the addition of enhanced emissions-control systems and improvements in inspection and maintenance programs in some areas. During this time, EPA and the states have also undertaken efforts to reduce emissions from electric utilities, chemical manufacturing, and other stationary sources that could have contributed to the improvements. Further, because ozone is more readily created when VOCs, NOx, and CO react in sunny and hot weather, meteorological fluctuations affect the relationship between emissions and ozone levels. For example, EPA has identified cases where air quality improved, but the improvement was largely due to better weather (more air circulation, lower amounts of heat and sunlight, and other factors). According to the National Research Council and others, determining how much air quality improvement is specifically attributable to any specific emissions control program, including special gasoline blends, would require the collection of high-quality, long-term data on air pollution, on other control measures, and on weather.

Use of Special Gasoline Blends Has Made It More Complicated and Costly to Supply Gasoline

The increasing numbers of special gasoline blends have made it more complicated and costly to supply gasoline, elevating the risk of localized supply disruptions. Producing special gasoline blends can require changes at refineries, making it more complicated and costly to produce gasoline. Special blends also add to the number of fuels shipped through pipelines, reducing the efficiency of the pipelines and raising costs. In addition, because the tanks at the fuel terminals were often built before the proliferation of blends, they are often too large and too few to efficiently handle the increased number and smaller size batches of special gasoline blends and, as a result, total storage capacity has fallen. Further, in some cases, the proliferation of blends has reduced the supply options available to some retailers, making them more susceptible to supply disruptions.

Making Special Gasoline Blends Has Added Complexity and Costs at Refineries

Producing some special gasoline blends sometimes requires refineries to invest in additional refinery units, making their refineries more complex, or reducing their capacity to make gasoline. For example, producing cleaner-burning fuel with lower levels of toxic and other emissions, such as RFG or CBG, has required some refiners to install specialized units that remove sulfur and benzene during the refining process. Similarly, production of low-RVP gasoline requires that refiners leave out the lightest components typically included in conventional gasoline. Separating these components or converting them to ones that can be used in these blends may require additional refinery units. If the components are not immediately used in gasoline at that refinery, they may be stored, may be used in less valuable fuels such as diesel or jet fuel, or shipped to other refineries that can use these components. The removal and additional processing of these components can decrease the amount of gasoline a refinery can produce. For example, officials from one California refinery told us that their refinery could produce 12 percent more volume if it produced conventional gasoline rather than California gasoline because conventional gasoline uses more of the components that are typically generated in the refining process.[19]

Adding refinery units and losing refinery capacity can increase the overall costs of refining gasoline. Manufacturing low-RVP fuel generally involved reducing the use of some components and, as a result, was less costly than the more significant changes needed to make the cleanest burning blends. Specifically, in 1996, EPA estimated that low-RVP blends cost 1-2 cents per gallon more to make than the conventional gasoline at the time. In contrast, in 2003, the Energy Information Administration (EIA), within the Department of Energy, estimated that blends formulated to meet the most stringent standards, such as oxygenated California gasoline, cost 5-15 cents more per gallon to make than the conventional gasoline required at the time and that RFG generally costs 2.5-4 cents more per gallon to make.

In addition, the use of oxygenates in blends such as RFG further increases the complexity and cost of the refining process because refiners must either invest in equipment to produce oxygenates from crude oil (in the case of MTBE) or they must purchase these components from other sources. MTBE is generally less expensive than ethanol as an oxygenate but has raised water quality concerns. As described earlier, ethanol is generally shipped by truck or rail, stored separately from other gasoline components, and blended just before gasoline is sent to retail stations. The higher cost of purchasing ethanol during the period of our analysis, together with these separate handling procedures, adds to the total cost of

[19]While the switch from conventional gasoline to a special gasoline blend has led to reductions in refining capacity, all other things equal, refiners, in investing in new processes to make the special blends, have also typically increased the capability of their refineries to convert less valuable components to more valuable ones, thereby increasing their capacity.

making ethanol-blended gasoline. Additionally, because ethanol has a high RVP, more components must be removed from ethanol-blended gasoline than from MTBE-blended gasoline to meet specifications for RVP. Removing these components and reprocessing them or diverting them to other products increases the cost of making ethanol-blended gasoline.

Shipping More Special Gasoline Blends Reduces Pipeline Capacity and Raises Costs

Shipping gasoline on a pipeline requires a great deal of coordination between refineries, pipelines, and terminal stations to maintain pipeline flows while fuels are being added and withdrawn. Pipeline operators told us that they develop schedules of when individual shipments (called batches) will occur at least 1 month in advance; however, some changes to this schedule may occur up to the date when a product is placed on the pipeline to adjust for, among other things, the need for more of a specific gasoline blend in some locations. On the day of shipment, pipeline operators precisely coordinate when refineries or other shippers add or "inject" fuel to the pipeline and when fuel is taken off of the pipeline along with other aspects of operating the system. Companies shipping fuel on the pipeline, may request to keep their products isolated from others (a segregated batch) or may choose to combine their product on the pipeline with other blends meeting similar or identical product specifications (a fungible batch). Because of the large number of gasoline blends and, because some shippers require segregated batches, the number of fuels shipped in pipelines has increased dramatically in recent years. For example, one pipeline company noted that in 1970 they shipped 10 different products on their system over the entire year, whereas in 2004 they shipped 128 (including distinct blends and segregated products).[20]

The increased number of special gasoline blends has reduced the effective capacity of the nation's petroleum products pipeline infrastructure because the pipelines are generally operated at slower speeds to accommodate more and smaller batches of gasoline while keeping the different blends separate. The speed at which centrally controlled pumps move product along pipelines—typically between 3 and 8 miles per hour—can be affected by a number of factors, including the volume of product relative to the

[20]Many of the pipelines that transport gasoline also ship other petroleum products such as diesel fuel, jet fuel, and propane—some of which also require multiple, although fewer, formulations. Recent regulations that will require lower levels of sulfur in some diesel fuels will further increase the number of fuels moving through the pipeline infrastructure and may cause other complications in maintaining fuel quality and are expected to have similar effects as special gasoline blends.

pipeline capacity being shipped, the size of batches, and the availability of terminal storage along the pipeline route. Several pipeline operators told us that, prior to the introduction of special gasoline blends, they shipped many fewer products and much larger batches than they do now. Further, they said that shipping smaller volumes can require them to slow or stop the pipeline to allow shippers to inject or withdraw individual fuels at fuel terminals or other locations. Lost opportunities associated with reductions in the amount of fuel that the pipeline can transport serve to raise the average cost of moving gasoline.

The increased number of fuels and fuel types shipped on pipelines has also increased losses and costs associated with mixing of fuels. Two types of fuel mixtures occur at the interface between batches on pipelines: downgrading and transmix. Downgrading occurs when two similar fuels mix, but the resulting mix no longer meets the more valuable product specification. For example, if a high- and regular-octane gasoline are mixed, then the downgraded gasoline may be sold only as lower-priced, regular gasoline. Transmix results when two dissimilar fuels mix and the fuel cannot be used without reprocessing. For example, if diesel fuel and gasoline mix, the transmix must be processed to separate the fuels into usable products. Similarly, because MTBE is banned in some areas, if gasoline blends containing MTBE come in contact with other fuels, the mixed fuel is considered transmix and must be reprocessed to remove the MTBE before it can be used. To minimize losses associated with downgrades and transmix and still maintain efficiency, pipelines generally set a minimum batch size. Several pipeline operators reported that they have witnessed increased losses and costs due to downgrades and because more fuel requires reprocessing as the number of special gasoline blends has increased.

In addition, according to some pipeline company officials, because some gasoline blends are only used in one city or only in some areas served by a pipeline, shippers incur additional costs if these gasoline blends are not taken off the pipeline at the right location. For example, one pipeline operator told us that RFG with MTBE shipped in Midwest pipelines cannot be used without costly reprocessing if it is shipped past certain points on these pipelines because no regions beyond these points allow the use of RFG with MTBE. In some instances, the pipeline may need to be slowed, or even stopped, to allow a special gasoline blend to be taken out of the pipeline.

Increased Numbers of Gasoline Blends Reduce Terminal Storage

The increased number of petroleum products generally, including special gasoline blends, and the need to keep them separated, has reduced the storage capacity of some gasoline terminals which can create difficulties during periods when gasoline supplies are disrupted. To ensure product quality, special gasoline blends must be stored in separate tanks. Several terminal operators told us that their terminals were built before the proliferation of special gasoline blends and were designed to handle fewer, but larger, batches of gasoline. Terminal operators told us that, because many of the special gasoline blends are shipped in smaller batches, the tanks used for these blends are often not filled to capacity. One terminal operator told us that some new storage tanks had been built in recent years. This operator went on to say that adding new storage capacity at existing terminals is often either prohibitively expensive or extremely difficult because of space limitations and the need to obtain federal, state, and local regulatory approvals. One terminal operator told us that the company has chosen not to carry one or more gasoline blends used in its area because the company's existing tanks were insufficient and building additional tank capacity was too costly. For these same reasons, it is often difficult to build new terminals. In addition to the complexity of these factors, terminal operators told us that the proliferation of special gasoline blends also raised their costs by reducing their ability to fully utilize their existing tanks, which cost them the opportunity to store additional fuels, or by forcing them to make additional investment to build more tanks, or both.

In addition, terminal operators told us that reduced storage capacity at their facilities, combined with the increased number of fuels in the pipeline system, has made it more difficult to maintain adequate stockpiles of some gasoline blends. Several pipeline operators said that the interval between when a fuel is available from the pipeline may be 10 days or longer if capacity is not available on the pipeline—requiring that many days' worth of fuel to be stored at the terminal. Increasing demand for gasoline combined with this longer period between shipments, and limited terminal storage, increases the likelihood that some areas will run out of gasoline while waiting for a shipment. One pipeline operator said that the terminals that they served did not run out of gasoline from 1995-1996, but that now one terminal per month runs out of fuel. One terminal operator explained that running out of gasoline can be very harmful to their business because terminal operators rely on retailers and independent gasoline tanker trucks to regularly visit their stations—visits that may not occur if their supplies are inconsistent. In addition, the operator told us that, when tanks are pumped dry and later refilled, they can release up to 1 ton of VOCs, which contributes to pollution. While the terminal operators we spoke with said they are generally able to maintain sufficient gasoline storage, they can run short of some fuels when demand is high or pipeline deliveries are delayed or interrupted. One operator noted that they increase their wholesale gasoline prices as their available supplies fall in an effort to reduce their sales and retain some gasoline for sale and avoid running out. The terminal operators we interviewed did not provide us data on the number of instances when they ran out of gasoline, but they said that the number has significantly increased in recent years.

Special Blends Limit Supply Options in Wholesale Markets When Local Supply Disruptions Occur

According to operators of independent retail gasoline stations that buy from the wholesale markets, they have more limited supply options as a result of the presence of special gasoline blends. According to an industry representative, some gasoline retailers affiliated with, or owned by, large oil companies (so-called “integrated” oil companies, such as ExxonMobil and ChevronTexaco) receive their gasoline—referred to as branded gasoline—only from these companies, generally paying slightly more for it. However, other companies that are not affiliated with these integrated oil companies, referred to as independent retailers, typically purchase gasoline from a variety of suppliers including, but not limited to, integrated oil companies and typically purchase gasoline at the lowest price available from nearby fuel terminals. As a result of this and other factors, independent retailers said that they generally sell gasoline at a lower price than branded gasoline stations. According to some, the introduction of special gasoline blends may increase the market power of some refiners. In its 2001 white paper, EPA noted that the development of special blends limits competition in the refining sector because some blends are small, and only a few refiners may choose to make some blends. Consistent with this view, independent retailers told us that they have had fewer choices in some markets near where special gasoline blends are required because some refineries and fuel terminals no longer sell gasoline for those markets, and that they have tended to pay higher prices in those areas. For example, one large independent retailer operating retail gas stations on the East Coast told us that the number of refineries producing gasoline for the market they serve fell from 12 to 3 after the introduction of special gasoline blends—leaving the retailer with fewer options to identify the lowest cost supplies. Special gasoline blends have also complicated the ability of some large entities to enter local gasoline markets. Officials with a large company that has entered several local gasoline markets across the country as an independent retailer told us that obtaining sufficient supplies at reasonable prices is more difficult in markets where special gasoline blends are used and that limited supply options have reduced the company's ability to enter and compete in some of these markets.

The plight of independent retailers is particularly pressing when traditional supplies are disrupted. The independent retailers that we spoke with said that their prices generally increase first and that they may not have access to fuel supplies provided to branded retailers if supplies are disrupted. Before special gasoline blends, these independent retailers were able to truck fuel in from nearby cities or neighboring states, however, because some gasoline blends may not be used anywhere else, or they may only be used hundreds of miles away, this is a more difficult and costly option today. For example, several industry officials noted that, if supplies of California gasoline are disrupted, they would expect prices to rise and that it could take weeks for additional supplies to arrive. They said that nearby suppliers capable of blending California's gasoline blend are generally operating close to their full capacity. In the event that these supplies are disrupted, additional supplies generally come from Western Canada, the Gulf Coast, the Caribbean, or farther away, because there are only a few refineries capable of making this special gasoline blend and, as a result, supplies could take 3 weeks or more to arrive.

Areas That Use Uncommon Special Gasoline Blends Tend to Have Higher and More Volatile Gasoline Prices

Among the 100 cities we examined, the highest wholesale gasoline prices tended to be found in cities that used a special gasoline blend not widely available in the region or that is more costly to make than other blends. Cities that are far away from major refining centers or other sources of gasoline also tended to have high prices. Prices also tended to be more volatile in cities having one or more of these characteristics. Other studies have also found higher and/or more volatile prices in some cities that use special gasoline blends. Greater complexity and higher refining, transportation, and storage costs associated with supplying special gasoline blends have likely contributed to increased gasoline prices overall, and for specific special blends, but it is not possible to conclusively determine the extent to which special gasoline blends have caused the higher prices and greater volatility found in specific cities.

We Found Higher and More Volatile Gasoline Prices in Cities That Use Special Blends

We examined data from 100 selected cities to determine how prices varied across areas that use special gasoline blends versus conventional gasoline and found that, with some exceptions, the highest and most volatile gasoline prices tended to be found in cities that used special gasoline blends that are uncommon or particularly expensive to make, or in cities that are long distances from major refining areas. Each of these factors tends to isolate a city from the overall gasoline market by limiting the available supplies of gasoline from other areas in the event there is a supply shortfall in that city.

With regard to special gasoline blends, the data show that most of the 20 cities with the highest average prices over about the past 4 years (December 2000 through October 2004) used special gasoline blends, most of them formulated to meet stringent emissions standards. In many cases, these cities used a fuel that is not widely used outside their area, or in some cases is unique to that city or state. For example, the five California cities in the data set are all in the top 20 cities with respect to gasoline prices. California's gasoline is the cleanest-burning gasoline and, in order to make it, California's refineries have invested substantial capital in new refining processes. Further, only a few refineries outside of California routinely make California gasoline, the closest of which is in Northern Washington. The uniqueness of California's gasoline has been noted by many sources as likely contributing to California's high gasoline prices relative to the rest of the country. For the period we examined, the five cities we looked at in California had average prices ranging from about 24 to 26 cents per gallon more than the city with the lowest price (Meridian, Mississippi), which uses conventional gasoline and is located near the large refining center in the Gulf Coast. The table in appendix II shows the price data and gasoline blend types for each of the 100 cities we evaluated. Some of the cities with the highest prices used conventional gasoline year-round, but most of these are far from major refining areas or are located on or near a single smaller pipeline. Average prices in these top 20 cities were between 14 and 41 cents per gallon more than in the city with the lowest price.

Using ethanol as an additive to gasoline is associated with higher wholesale gasoline prices. To evaluate this, we examined national average prices for gasoline blends containing ethanol. For example, for the nation as a whole, average prices for conventional gasoline with ethanol were about 4 cents per gallon higher than conventional without ethanol over the time period we analyzed. The switch to using ethanol, as opposed to MTBE, was also associated with higher gasoline prices.[21] For example, in the years 2001-2003, during which California phased out MTBE and phased in

[21]As discussed in this report, the switch to ethanol from MTBE has largely been the result of MTBE's tendency to contaminate ground water sources.

ethanol, the average summer price of gasoline with ethanol was between about 4 and 8 cents per gallon more than the price of gasoline with MTBE. Similarly, over the period 2001-2004, the average summer price for federal reformulated gasoline with ethanol was between about 6 and 13 cents per gallon more than for federal reformulated gasoline with MTBE.

In contrast to the highest-priced cities, the 20 cities with the lowest average wholesale gasoline prices over the period typically used common gasoline blends and/or were located near a major refining center—most often near the Gulf Coast, the largest refining center in the country in terms of both numbers of refineries and total refining capacity. For example, among the 20 cities with the lowest prices, 8 used conventional gasoline—the most widely available gasoline blend. Conventional gasoline is used extensively across the United States, and most cities that use it are surrounded by areas using the same gasoline. Another 9 cities with the lowest prices used 7.8 RVP gasoline—the most widely used of the special blends and the one formulated according to the least stringent emissions standards. Most of the 7.8 RVP gasoline is used in areas close to the Gulf Coast refining center. In addition, refiners told us that making 7.8 RVP gasoline is simpler and less costly than some of the other blends, so it may be more available from refineries in the event of a local supply shortfall. The other 3 cities with the lowest prices used less common special blends but are all close to the largest refining center, the Gulf Coast and, therefore, have many more potential supply options than more isolated cities do.

We found similar results with regard to the volatility of gasoline prices.[22] For example, 18 of the 20 cities with the most volatile prices used special blends of gasoline, and many of these cities were also among the highest-price cities. In contrast to the cities with relatively high price volatility, 17 of 20 cities with the lowest volatility use either conventional or 7.8 RVP gasoline. However, while prices for special blends tend to be higher and more volatile than prices for conventional gasoline, available data did not allow us to attempt to isolate the effects of specific special gasoline blends on gasoline prices or to definitively establish a causal link between specific special blends and price volatility. Specifically, we did not have sufficient data to control for all other potential contributing

[22]We measured volatility for each city as the standard deviation across time of the city price minus the price of West Texas Intermediate crude oil—a widely used benchmark for crude oil, the principle physical input into gasoline. A more detailed description of our methodology can be found in appendix I.

factors—such as the distance from cities to the sources of gasoline supply, or other specific features of these cities that might influence prices regardless of the blend of gasoline used.

Other Studies Have Found Similar Results

We reviewed the literature associated with special gasoline blends and gasoline prices and found a number of studies done by government, academic, and private entities. The results and conclusions of these studies were largely consistent with our findings. For example, a recent EPA study found that high prices and price volatility are most acute in isolated markets, particularly those using special gasoline blends.[23] The study also pointed out that some states had adopted specific gasoline blends in an attempt to use a blend that had a lower refining cost than federal reformulated gasoline. EIA also studied these blends and concluded, among other things, that the increasing number of distinct gasoline blends has reduced the flexibility of the supply and distribution system to respond to unexpected changes in supply and demand for gasoline. EIA further pointed out that, in some cases, states have chosen low RVP gasoline blends in an attempt to achieve lower gasoline prices than if they had used federal reformulated gasoline, and they inadvertently may have added strain to the distribution system, leading to greater potential for price volatility. A number of other academic and private studies found similar results.

Special Gasoline Blends Contribute to Higher and More Volatile Prices, but Available Data Are Insufficient to Control for all Other Factors

There is a broad consensus among the experts and others we spoke with that the proliferation of special gasoline blends have contributed to increased and more volatile gasoline prices. The studies we reviewed also came to similar conclusions. Further, the greater complexity and higher refining, transportation, and storage costs associated with supplying special gasoline blends have almost certainly resulted in increased prices or volatility, either because of more frequent or severe supply disruptions, or because higher costs are likely passed on, at least in part, to consumers. For example, depending on the pipeline company, costs associated with downgrades or transmix are recovered from customers. At least part of these costs are, in turn, likely to be passed down the supply chain and eventually to consumers of gasoline. Similarly, the costs incurred to install

[23]EPA Staff White Paper, *Study of Unique Gasoline Fuel Blends ("Boutique Fuels"), Effects on Fuel Supply and Distribution and Potential Improvements*, EPA420-P-01-004, Office of Transportation and Air Quality, U.S. Environmental Protection Agency: October 2001.

new processes to make special gasoline blends are likely passed on, at least in part, to consumers because refining companies would not make these investments without a reasonable expectation of a return on their money.

While it is, therefore, almost certain that special gasoline blends have been a contributing factor to higher gasoline prices, it is not possible with the data available to us to conclusively determine the extent to which these blends have caused the higher prices and greater volatility found in specific cities or to rule out other potentially contributing factors. Such other factors may include specific supply infrastructure problems in or around these cities that would impact gasoline prices regardless of the blend. For example, state and industry officials in California told us that marine terminals for off-loading gasoline and other petroleum products are in short supply in California, which constrains the ability of suppliers in the state to receive these products from outside the state in the event of a local supply shortfall. These constraints would potentially contribute to higher gasoline prices regardless of which blend is used. Another potential factor that might influence gasoline prices independently of gasoline blends is the level of competition in the petroleum products industry. For example, in a recent GAO report, we found that oil company mergers had contributed to a 1 to 2 cent per gallon increase in conventional gasoline prices in the 1990s and as high an increase as 7 cents per gallon for California's special gasoline blend. In addition, there may be other such factors at play that we do not observe, so we cannot definitively determine the precise extent to which observed prices are the result of the proliferation of special gasoline blends.

Conclusions

Special gasoline blends have reduced emissions and helped contribute to improved air quality in some parts of the country. Using special gasoline blends to achieve air quality standards is attractive to states; the blends offer immediate reductions in emissions from all vehicles already on the road by varying degrees. Unfortunately, EPA's knowledge about the emissions generated when special gasoline blends are burned is outdated. Much has changed regarding vehicle and emissions control technologies since special gasoline blends, including those with ethanol, were last comprehensively tested in automobile engines. However, EPA and the states continue to rely on models built largely around these dated findings when evaluating whether to allow states to use special blends as a component in their efforts to improve air quality. Given the significant changes in vehicles and fuels, EPA should have better information about how the current fuels affect the vehicles currently on the road. In addition, Congress should have better information regarding the effectiveness of these blends, particularly those containing oxygenates such as ethanol, to aid in setting policy on fuel blends and the use of oxygenates.

Although special blends have helped reduce emissions and improve air quality, the introduction of these blends appears also to have divided the gasoline market, converting what had been closer to a single national commodity market, into islands of smaller and more local markets for blends of gasoline that are typically not interchangeable. Because of octane, seasonal, and other differences, each additional special blend that is added can require pipelines and fuel terminals to handle several additional blends. Overall, this transformation of the gasoline market has complicated the supply infrastructure, increased production and delivery costs, and reduced the availability of gasoline, in some cases. The impacts of the proliferation of special gasoline blends are most evident when there is a disruption in the supply chain, such as when a refinery or pipeline is shut down. In these instances, localities using a blend different from the gasoline used in nearby areas must seek replacement supplies from farther away, leading to delays that likely cause higher and longer price spikes until these supplies arrive. Overall, it is likely that gasoline prices are higher now than they would be if gasoline were closer to a single commodity.

In light of the opposing effects of environmental benefits and negative market implications, an ideal policy for approving the use of special gasoline blends would balance these effects. However, each decision involves trade-offs that all stakeholders may not value equally. Specifically, different stakeholders may attach varying degrees of importance to the environmental benefits or the impacts on gasoline supply infrastructure. Further, individual state actions that impact the entire regional supply infrastructure may not fully take those impacts into account or, in some cases, even accurately predict the impact on their own gasoline supply. With the 8-hour ozone rule and other regulatory changes likely to lead to more applications to use special gasoline blends, balancing the emissions effects of specific gasoline blends against the implications for supply and price will be even more important in the coming years. While EPA is currently authorized to approve state applications to use special gasoline blends, the agency cannot effectively weigh environmental and supply considerations because it does not have authority to deny state requests to use these blends on the basis of regional supply or price considerations and because its information on the environmental benefits is dated.

Recommendation for Executive Action

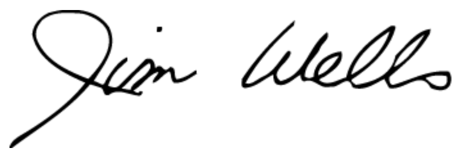
To provide a better understanding of the emissions impacts of using special gasoline blends and these blends' impacts on the gasoline supply infrastructure, we recommend that the EPA Administrator direct the agency to take the following four actions: (1) work with states and other stakeholders to comprehensively analyze how various gasoline blends affect the emissions of vehicles that comprise today's fleet, including how overall emissions are affected by the use of ethanol and other oxygenates; (2) use this updated information to revise the emissions models that states use to estimate the emissions and air quality benefits of these fuels and provide this information to Congress; (3) work with states, the Department of Energy, and other stakeholders to develop a plan to balance the environmental benefits of using special gasoline blends with the impacts on gasoline supply infrastructure and prices, and report the results of this effort to Congress; and (4) work with the states, the Department of Energy, and any other appropriate federal agencies to identify what statutory or other changes are needed to achieve this balance and report these findings to Congress and request that Congress provide these authorities to the appropriate federal agency or agencies.

Agency Comments and Our Evaluation

We provided a copy of our draft report to EPA for comment. The agency did not comment on our findings or recommendations but did provide technical comments that we have adopted, as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to other appropriate congressional committees and the Administrator of EPA. We also will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or wellsj@gao.gov. Contact points for our Office of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who contributed to this report are listed in appendix II.



Jim Wells
Director, Natural Resources
and Environment

Scope and Methodology

To determine the extent to which special gasoline blends are used in the United States and how, if at all, this use is expected to change in the future, we reviewed related literature, reviewed data on the use of these fuels, and interviewed government and other officials. Specifically, we reviewed reports on the presence and use of special gasoline blends by the Environmental Protection Agency (EPA), the Energy Information Administration (EIA), and others. We also examined data on the use of special gasoline blends provided by EPA, ExxonMobil (a commonly mentioned source of information on use of special gasoline blends), the Oil Pipeline Information Service, state environmental agencies and others. In addition, we interviewed federal and state government officials, academic and industry experts, and industry officials. Specifically, we interviewed officials with the EIA and EPA in Washington, D.C., as well as officials with EPA's Office of Transportation and Air Quality in Ann Arbor, Michigan, and officials in each of the 10 EPA regional offices. We also interviewed representatives from industry trade associations including the American Petroleum Institute, the Renewable Fuels Association, the National Petrochemical Refiners Association, the Association of Oil Pipelines, the National Association of Convenience Stores, the Alliance of Automobile Manufacturers, and the Society of Independent Gasoline Marketers and with representatives from the National Governors Association. In addition, we interviewed academic and industry experts, and industry officials from companies involved in refining, terminal operations, and pipeline operations, as well as from large oil companies. We also conducted site visits in California, Louisiana, New Jersey, Pennsylvania, and Texas—states with large refining sectors and/or organizations with experience with producing and using special gasoline blends.

To document what EPA and others have determined regarding the role of special gasoline blends in reducing vehicle emissions and improving overall air quality we reviewed related literature, interviewed federal, state, and other officials, and examined emissions estimates provided by EPA. Specifically, we examined reports on the emissions impacts of special gasoline blends done by EPA, the Auto/Oil Air Quality Improvement Research Program (AQIRP), National Research Council, state environmental agencies, and others. In addition, we interviewed federal and state government officials, academic and industry experts, and industry officials. Specifically, we interviewed federal officials at EPA and EIA, staff at state environmental offices, researchers associated with the National Academies of Science and the National Research Council, representatives from industry trade and health advocacy associations, including the American Petroleum Institute, the Renewable Fuels

Association, the National Petrochemical Refiners Association, the Association of Oil Pipelines, the National Association of Convenience Stores, the Alliance of Automobile Manufacturers, the Society of Independent Gasoline Marketers, and the American Lung Association. In addition, we interviewed academic and industry experts, and industry officials from companies involved in refining, terminal operations, and pipeline operations, as well as from large oil companies. To assess the reliability of emissions analyses, we reviewed the analyses' overall design and methodologies, including assumptions and inputs to modeling. Automobiles emit a number of harmful pollutants; however, some have been identified as potentially more significant than others. The Clean Air Act authorizes EPA to mitigate potentially harmful concentrations of major criteria pollutants, including carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), particulate matter (PM) and lead (Pb). GAO focused its analysis on VOC, NOX—important precursors to ozone—and CO emissions because the transportation sector is responsible for a large fraction of VOC, NOx, and CO emissions in the United States and, as a result, the Clean Air Act and EPA have specified the reduction of these pollutants through fuel control programs.

To identify what effects, if any, special gasoline blends have on gasoline supply in the United States, we examined literature reporting on the effects of special gasoline blends on gasoline supply, interviewed government officials and a wide cross section of industry participants. Specifically, we interviewed agency officials with EPA, EIA, the Federal Trade Commission, and state regulatory agencies. In addition, we interviewed representatives from industry trade associations, including the American Petroleum Institute, the Renewable Fuels Association, the National Petrochemical Refiners Association, the Association of Oil Pipelines, the National Association of Convenience Stores, the Alliance of Automobile Manufacturers, and the Society of Independent Gasoline Marketers. We also interviewed petroleum industry officials from companies involved in refining, terminal and pipeline operations, and marketing, including interviews with senior industry officials from several integrated oil companies such as ExxonMobil, ChevronTexaco, five operators of large pipeline systems that carry multiple gasoline blends, several operators of terminals, and three large independent marketers of gasoline that buy wholesale gasoline and sell it to retail customers. We also conducted site visits in California, Louisiana, New Jersey, Pennsylvania, and Texas—states with large refining sectors and/or organizations with experience with producing and using special gasoline blends.

To determine how these blends affect gasoline prices, we examined the literature on gasoline prices, interviewed industry officials and experts, and analyzed wholesale gasoline price data. We reviewed reports on the use of specials gasoline blends and gasoline prices done by EPA, EIA, and others. We also interviewed government officials and industry experts including federal officials at EPA and EIA; staff at state environmental offices; academic and industry experts; petroleum industry officials from companies involved in refining, terminal operations, and pipeline operations, as well as from large oil companies; and representatives of trade associations.

In addition, we evaluated data on wholesale gasoline prices in 100 cities provided by the Oil Price Information Service (OPIS), as well as data on national average prices[1] from the same source—these national data covered all the terminals in the country for which OPIS collects data. The data were weekly average prices from terminals selling gasoline at wholesale and covered the period from December 2000 through October 2004. In choosing which cities to evaluate, we first selected all cities on major pipelines. Then we selected the largest cities in each state and in each contiguous area that used a special gasoline blend. In so doing, we chose at least one such city from each contiguous area in the United States that we determined used a special blend of gasoline. Then, we chose cities in areas that use conventional gasoline, using similar criteria—every conventional-gasoline city chosen was the largest city in its respective state that was on a major pipeline. We did not estimate an econometric model to try to isolate the effects of specific special blends because we felt we lacked sufficient data to control for all other potential contributing factors—such as specific features of these cities that might influence prices regardless of the blend of gasoline used or the degree of competitiveness in the gasoline supply industry. Instead, we ranked the 100 cities according to the mean of their gasoline prices to determine if there were consistent patterns with respect to areas that use special gasoline blends versus areas that use conventional gasoline. To calculate the mean, we first created price differentials between each week's price in each city and the price per gallon of West Texas Intermediate crude oil—a commonly used benchmark for world crude oil prices. These crude oil prices came from Platts, a

[1]Wholesale prices are the prices reported by fuel terminals and did not include any relevant taxes. According to OPIS, in some cases fuel terminals may have reported tax credits available for ethanol fuels in the prices that they reported, but they acknowledge that past reporting may be inconsistent in this regard.

common source for crude oil and petroleum product prices. For each city, we performed a statistical test comparing the average prices between each city and two comparison cities in Texas[2].

We also ranked the cities according to the standard deviations of their prices over time and looked for similar patterns. To calculate the standard deviations, we again created price differentials between each week's price in each city and the price per gallon of West Texas Intermediate crude oil. Creating a differential between gasoline and crude oil prices controls for some volatility in gasoline prices that is caused by changes in the price of crude oil, the fundamental raw material input in gasoline. Then, we calculated the standard deviation over time for each city for these price differentials. The standard deviation is a common measure of the variability of data and, in this case, is a measure of how much the prices in each of the cities varied over time, controlling for crude oil prices. For each city, we performed a standard test for statistical significance of the difference of the variability between that city and the city with the lowest standard deviation.[3]

[2]Specifically, we performed a sign test. See, for example, R.V. Hogg and A. T. Craig, *Introduction to Mathematical Statistics*. 4th ed. (New York: Macmillan, 1978): 312-314. We use the sign test because it tests the equality of matched pairs of observations without imposing further assumptions on the underlying distributions. The results of this test showed that all the highest 20 city prices were statistically significantly greater than in the low price comparison city.

[3]H. Levene, "Robust tests for equality of variances," ed. I. Olkin, *Contributions to Probability and Statistics* (Palo Alto: Stanford University Press, 1960): 278-292. We use the Levene test because the conventional F test is very sensitive to the assumption that the data are drawn from a Normal distribution, an assumption that does not necessarily hold for the gasoline price data. This test indicated statistical significance for the difference between the variances of most of the highest volatility cities compared to the lowest volatility city.

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Staff Acknowledgments

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