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Report to the Chairman, Committee on Science and Technology, House of Representatives

September 2008

MOTOR FUELS

Stakeholder Views on Compensating for the Effects of Gasoline Temperature on Volume at the Pump

GAO-08-1114

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GAO Accountability • Integrity • Reliability

Highlights

Highlights of GAO-08-1114, a report to the Chairman, Committee on Science and Technology, House of Representatives

Why GAO Did This Study

The volume, but not the energy content, of hydrocarbon fuels, such as gasoline and diesel, varies in response to changes in temperature. Thus, because of expansion, the energy content per gallon of 90 degree fuel is less than that of 60 degree fuel. States and localities adopt and enforce weights and measures regulations, often using the model regulatory standards published by the National Institute of Standards and Technology (NIST). Although technology now exists to compensate for the effects of temperature on gas volume, the costs of doing so at the retail level have become the subject of much debate among weights and measures officials, consumer groups, and representatives of the petroleum and fuel marketing industries.

GAO was asked to provide information on (1) the views of U.S. stakeholders on the costs to implement automatic temperature compensation, (2) the views of U.S. stakeholders on who would bear these costs, and (3) the reasons some state and national governments have adopted or rejected automatic temperature compensation. To do this work, GAO reviewed NIST and other documents and congressional testimony; interviewed stakeholders from 3 federal agencies, 17 states, and 15 groups representing a variety of interests, including consumers, truck drivers, and the oil and gas industry; and interviewed officials in 5 other nations.

Various stakeholders and officials provided technical and other comments, which were incorporated in the report as appropriate.

To view the full product, including the scope and methodology, click on GAO-08-1114. For more information, contact David Maurer at (202) 512-3841 or maurerd@gao.gov.

What GAO Found

The costs to implement automatic temperature compensation are unclear. Most stakeholders said that implementing automatic temperature compensation for retail sales would involve the cost to purchase, install, and inspect new equipment on pumps, as well as costs to educate consumers about the change. Some stakeholders said the costs to adopt automatic temperature compensation ranged from $1,300 to $3,000 per pump, but none had estimated the total costs nationwide, in part because complete data are not available. Estimates of the cost to inspect the new equipment varied. Officials in a small number of states said inspection times would increase by 20 to 50 percent, while officials in three other states said the costs would not be significant. No stakeholders had developed estimates of the costs to educate consumers.

Stakeholders differ on whether retailers, consumers, or both would ultimately bear the costs of implementing automatic temperature compensation at the retail level. Some stakeholders, including state officials and industry representatives, said that the costs would be passed on to consumers through higher prices for fuel or other goods sold at retail stations. Others, such as consumer groups, said that retailers and consumers would share the costs and benefits. That is, some retailers could use funds they receive from major oil companies for remodeling to pay for the equipment. These stakeholders also said the benefits include consistent energy content for consumers and improved inventory management for retailers. Stakeholder views were largely based on professional judgment and general economic theory rather than on studies or other data, and most stakeholders said that a comprehensive cost-benefit analysis would provide policymakers with important information.

Governments that have adopted or permitted automatic temperature compensation for retail fuel sales cited improved measurement accuracy and greater equity between retailers and consumers as reasons for making the change; those that have prohibited it largely cited concerns that the costs would outweigh the benefits. Hawaii adopted temperature compensation more than 26 years ago because it provided purchasing equity for the industry and consumers. In 2008, Belgium mandated temperature compensation to help ensure more consistent energy content for consumers. Canadian officials cited improved measurement equity and accuracy as reasons for allowing retailers to sell temperature-compensated fuel in the early 1990s. In the United States, officials from eight states that have laws or regulations that prohibit automatic temperature compensation said the decision should be based on an analysis of the costs and benefits, with some expressing concern that the costs would outweigh the benefits. None of the governments that have adopted automatic temperature compensation have studied its impact.

Contents

Abbreviations

EPA	Environmental Protection Agency
EU	European Union
FTC	Federal Trade Commission
NCWM	National Conference on Weights and Measures
NIST	National Institute of Standards and Technology

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United States Government Accountability Office
Washington, DC 20548

September 25, 2008

The Honorable Bart Gordon
Chairman
Committee on Science and Technology
House of Representatives

Dear Mr. Chairman:

Consumers and businesses alike are concerned about the steep rise in fuel prices in recent years. Because the volume of hydrocarbon fuels, such as gasoline and diesel,[1] varies in response to changes in temperature, some are concerned about the potential impact of temperature-related changes in volume on the amount they pay. More specifically, the volume of gasoline expands or contracts by 1 percent for each 15 degree increase or decrease in temperature, while the energy content of gasoline remains the same. For example, 10 gallons of gasoline at 60 degrees Fahrenheit (F) expands to 10.2 gallons of gasoline at 90 degrees F but maintains the same total energy content.[2] As a result, the average energy content per gallon of the 90 degree fuel will be less than that of the 60 degree fuel. In the United States, wholesale fuel transactions are routinely adjusted for temperature-related changes in volume. However, at the retail level, gasoline and diesel are sold by volume—specifically, 231 cubic inches per gallon—without regard to temperature, leading some to believe that the retail price of a gallon of fuel may not reflect its true value. Advances in measurement technology have allowed the development of devices that can automatically compensate for the effects of temperature on volume when dispensing fuel at retail gas pumps.[3] While some argue that extending temperature compensation to the retail level could provide greater transparency in fuel prices, others contend that the cost to upgrade existing equipment could be substantial and impose economic hardship on retailers.

The National Conference on Weights and Measures (NCWM), a consensus-building organization composed of state and local regulatory officials and

[1]This report focuses on gasoline and diesel rather than other petroleum products, such as heating oil or jet fuel.

[2]This example assumes the use of the same blend of gasoline. Energy content can also vary depending on the blend of gasoline.

[3]Throughout this report, we refer to the devices that dispense fuel as pumps. Individual pumps may dispense multiple types of fuel, such as regular and high-octane gasoline.

other interested parties, has discussed whether to adopt standards for temperature compensation of gasoline and diesel for over 30 years, most recently at its meeting in July 2008. NCWM plays a key role in the debate because states adopt and enforce weights and measures regulations.

NCWM receives technical guidance on this and other matters from the Office of Weights and Measures in the Department of Commerce's National Institute of Standards and Technology (NIST). In partnership with NIST, NCWM develops model regulatory standards that are available for adoption and enforcement by state or local weights and measures authorities. NIST publishes these standards in various handbooks, and any proposed changes to these handbooks are considered by NCWM.

Since 2000, NCWM has considered various proposals related to automatic temperature compensation, including proposals in 2007 and 2008 to adopt model regulatory standards that states could use to implement temperature compensation in retail sales of gasoline and diesel. Neither of the proposed model standards has been adopted. In addition to the deliberations of NCWM, the Congress has held hearings on the issue, and federal legislation has been proposed to require the use of temperature compensation in retail transactions. However, the economic implications of temperature-induced changes in the volume of motor fuels on the price of gasoline and diesel remains a topic of considerable debate, and the issue continues to elicit strong opinions, both for and against, from parties such as petroleum marketers, retailers, independent truckers, fleet owners, and consumer advocates.

In the context of this debate, you asked us to provide information on (1) the views of U.S. stakeholders[4] on the costs to implement automatic temperature compensation, (2) the views of U.S. stakeholders on who would bear these costs, and (3) the reasons some state and national governments have adopted or rejected automatic temperature compensation. For each of these issues, we agreed to report on the support, such as studies or data, that stakeholders use for their views.

To obtain information from U.S. stakeholders on the costs to implement automatic temperature compensation and who would bear those costs, we reviewed NCWM documents and congressional testimony and performed a

[4]Throughout this report, we use the word "stakeholder" to refer to domestic individuals and groups with an interest in the current debate in the United States on this issue, including NCWM, NIST, current and former government officials, consumer groups, representatives of the petroleum and trucking industries, and fuel retailers.

literature search to identify relevant documents and stakeholders likely to have a view on the implementation of automatic temperature compensation in the United States. To identify additional stakeholders, we asked each stakeholder we interviewed for recommendations of knowledgeable other entities and selected for interviews those who would provide us with a broad and balanced range of perspectives on temperature compensation of gasoline and diesel. We used a standard set of questions to interview each of these individuals to ensure we consistently discussed each aspect of automatic temperature compensation. Specifically, we interviewed representatives of two consumer advocacy groups, five fleet owners and operators, a former NIST official, and officials at seven organizations that represent independent truck drivers, the oil and gas industry, independent petroleum marketers, convenience store and truck stop owners, and the trucking industry. To obtain views from governments that have adopted or rejected temperature compensation, we contacted officials in 16 states that have taken specific steps to adopt or prohibit automatic temperature compensation. We also contacted officials in California who are conducting a cost-benefit analysis of temperature compensation. In addition, we contacted officials from Australia, Belgium, Canada, the United Kingdom, and a European weights and measures organization because literature and interviews indicated these governments had adopted or had considered implementing automatic temperature compensation. We also interviewed officials from the Environmental Protection Agency (EPA), the Federal Trade Commission (FTC), and NIST because these agencies help oversee the marketplace generally or oversee aspects of the retail petroleum industry. See appendix I for a more detailed description of the methodology we employed.

We conducted our work from March 2008 to September 2008, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for the information we present for each of our audit objectives.

Results in Brief

The costs to implement automatic temperature compensation are unclear. Stakeholders said that implementing automatic temperature compensation for retail fuel sales would involve costs to purchase, install, and inspect new equipment on fuel pumps, as well as costs to educate consumers about the change. Although some stakeholders had limited estimates for costs associated with the adoption of automatic temperature

compensation, ranging from $1,300 to $3,000 per pump for the costs to purchase and install automatic temperature compensation equipment, none had estimated the total magnitude of these costs nationwide. These estimates from stakeholders were generally consistent with information we obtained from equipment manufacturers. Specifically, costs ranged from $900 to $1,800 to buy a kit to retrofit an existing pump and $200 to install the kit. Stakeholders said the costs to adopt temperature compensation could be affected by such factors as whether the investment to adopt the devices occurred immediately or more gradually to accommodate routine replacement decisions by retailers. A small number of stakeholders said estimates of the magnitude of costs had not been developed, in part, because certain data are missing, such as the number of mechanical pumps still in use nationwide. Estimates of the cost to inspect the new equipment as part of state enforcement of weights and measures standards varied. Officials in a small number of states said inspection times would increase by 20 to 50 percent, while in three other states, officials said the costs would not be significant. However, none of these officials had estimated the costs. Finally, although adopting temperature compensation would require that consumers be educated about it, no stakeholders had developed estimates of the costs to, for example, provide disclosure on street signs, fuel pumps, and customer receipts.

Stakeholders differ on whether retailers, consumers, or both would ultimately end up paying the implementation costs. For example, some stakeholders, including state officials and industry representatives, said that the costs of implementing automatic temperature compensation would be passed on to consumers. In their view, the costs to purchase and install compensation equipment would be passed on to consumers through higher prices for fuel or other goods purchased at retail fueling stations. Other stakeholders, such as consumer groups, said that retailers and consumers would share both the costs and the benefits of implementing temperature compensation. That is, one stakeholder said some retailers could use funds provided to them by major oil companies for remodeling to pay for the equipment. Consumers, they say, currently pay retailers for energy content they do not receive when they buy fuel that is warmer than 60 degrees F. Moreover, these stakeholders said that consumers would gain by receiving more consistent energy content, and one said that retailers would benefit because the automatic temperature compensation technology would make it easier to detect gas leaks and to manage inventory. Stakeholder views were based on professional judgment, general economic theory, and assumptions about how the fuel market operates rather than on studies or other data, and most stakeholders said

that a comprehensive cost-benefit analysis would provide policymakers with important information.

Governments that have adopted or allowed automatic temperature compensation cited improved measurement accuracy and greater equity between retailers and consumers as reasons for making the change, whereas those that had not adopted automatic temperature compensation cited concerns that the costs would outweigh the benefits. For example, Hawaii adopted temperature compensation more than 26 years ago because, according to Hawaiian officials, it provided purchasing equity for both the industry and the consumer. According to Belgian officials, Belgium mandated temperature compensation beginning in January 2008 to help ensure greater consistency in the energy content of the fuel sold to consumers. To improve measurement accuracy and equity, among other things, Canada developed standards in the early 1990s that allowed, but did not require, retailers to sell temperature-compensated fuel, according to a Canadian official. In the United States, officials from eight states that prohibited automatic temperature compensation said the decision should be based on an analysis of the costs and benefits, with some expressing concern that the anticipated costs would outweigh any benefit to consumers and fuel retailers. Governments have not formally studied the impact of their decisions to implement or allow automatic temperature compensation. Specifically, neither Hawaii nor Canada has studied the impact of temperature compensation, although officials reported it had been well accepted by both consumers and the industry and was not controversial. In Belgium, temperature compensation has not been in effect long enough to study its impact.

Background

From the beginning of the modern petroleum industry in the early 1900s, both industry and the federal government have recognized the problem that temperature-induced changes in volume present for inventory control. Specifically, the fact that petroleum products, like most other substances, expand when heated and contract when cooled means that the amount of fuel in the inventories of retailers changes, literally, with the weather. Following a study of the issue conducted by the American Petroleum Institute from 1912 to 1917, the United States and Great Britain established the standard measure for petroleum products: at an ambient temperature of 60 degrees F, 231 cubic inches equals a gallon.

The effect of temperature on fuel volume varies depending on the density of the fuel. For example, gasoline's volume changes approximately 1 percent for every 15 degree temperature change, whereas diesel, which is a more dense fuel, changes approximately 1 percent in volume for every 22

degree temperature change. In practice, the density of gasoline and diesel sold to consumers varies depending on such things as the crude oil used to produce the fuel and the addition of other components to achieve certain ends. For example, federal efforts to reduce petroleum consumption and greenhouse gas emissions require the increased use of some components in fuel blends, such as ethanol, biodiesel, and other alternative fuels. In addition, ethanol is added to gasoline in certain geographic areas to help reduce the emissions that contribute to the formation of ground-level ozone, which has been linked to respiratory and other health problems. As a result, the composition and density of gasoline and diesel products vary considerably across the country. In 2004, at least 45 different kinds of gasoline were produced in the United States.

Certain properties of fuels other than volume, such as mass and energy content, do not change in response to changes in temperature. However, energy content can be affected by changes in the density of fuel that arise from the addition of alternative fuels or other blending components that have densities different from the gasoline itself.

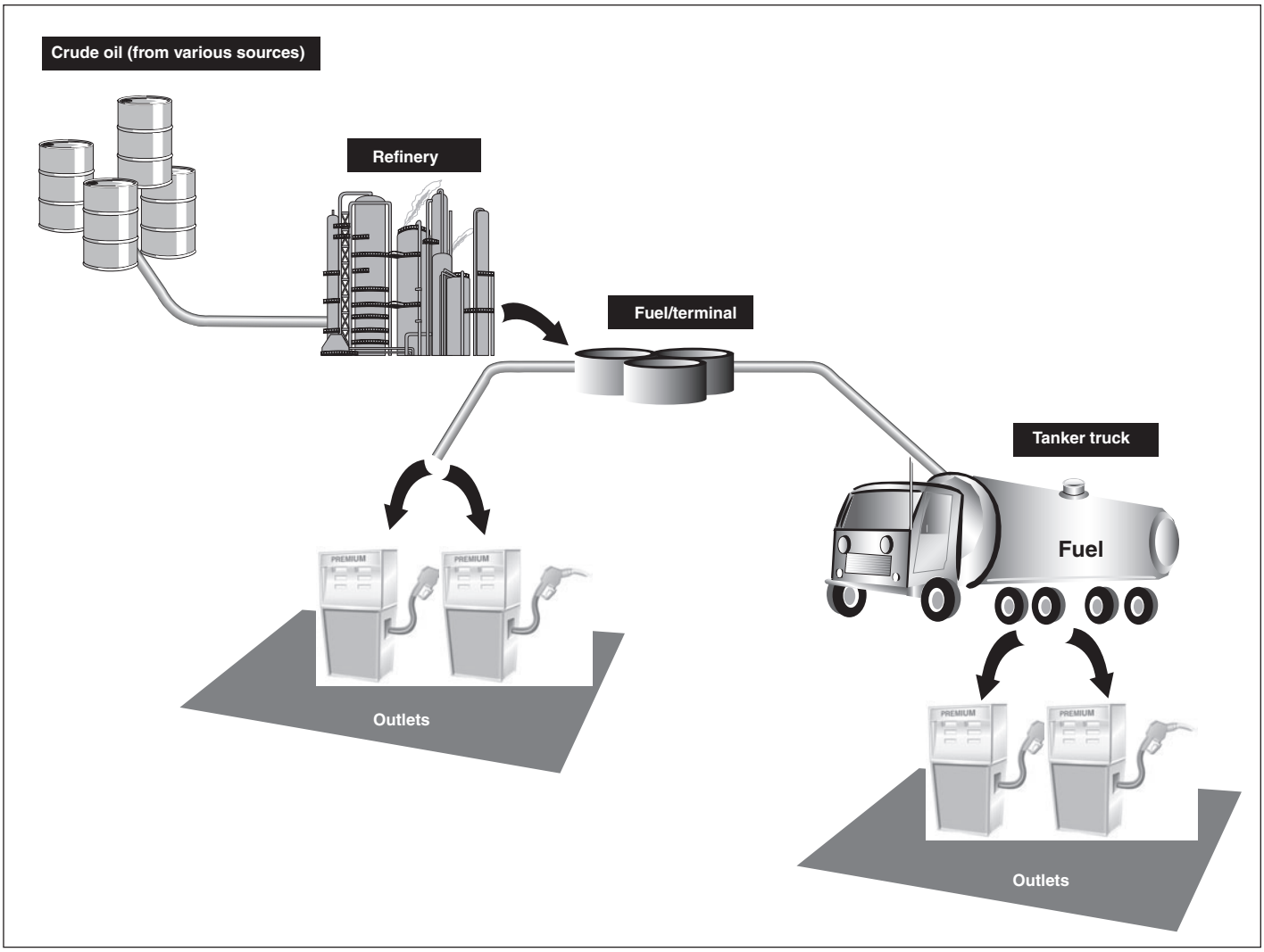
In the United States, the petroleum industry often adjusts for temperature-related changes in wholesale transactions for gasoline and diesel and in retail sales for other petroleum products, such as home heating oil, liquefied petroleum gas, and prepackaged liquids such as motor oil. In contrast, virtually all gasoline and diesel sold at the retail level is sold at 231 cubic inches per gallon regardless of the temperature of the fuel.

Temperature compensation can be achieved through several methods. First, volumetric changes can be calculated manually when the fuel density and temperature are known. Second, technological advances have led to the development of devices that automatically measure both the volume and temperature of the fuel at the time of purchase and correct the volume to the amount that would exist if the fuel were at 60 degrees F. Finally, in areas where the ambient temperature remains relatively constant throughout the year, pumps can be recalibrated to dispense the volume a gallon would occupy at 60 degrees F. For example, if the temperature in an area is relatively constant at 75 degrees F, pumps can be recalibrated to dispense 233 cubic inches per gallon.

Gasoline and diesel are distributed nationwide to fuel wholesalers through a supply infrastructure composed of pipelines, barges, tanker vessels, marine terminals, railroads, trucks, and storage tanks. At various points along the distribution chain, fuel is stored at terminal stations that generally have several large storage tanks. Fuel is then distributed, usually

by trucks, to retail gasoline stations, where it is typically stored in underground tanks (see fig. 1).

Figure 1: Distribution Network for Gasoline and Other Petroleum Products



Sources: GAO and Art Explosion (clip art).

Changes in the temperature of gasoline and other petroleum products can occur for several reasons from the time these products leave the refinery until they are deposited into a vehicle. For example, retail fueling stations located near a refinery or a pipeline may receive fuel that is still hot from the refining process, and the heated fuel will affect the temperature of the

fuel already in the storage tank.[5] In addition, the use of underground storage tanks—particularly those with double walls—may lengthen the time required for the fuel to cool to ground temperature of about 55 degrees F. A common misconception is that the use of underground storage tanks helps ensure that fuel remains at or below 60 degrees F. According to a 2004 NIST study based on 2 years of data, the average temperature nationwide for fuel stored underground was about 64 degrees and varied among states from about 82 degrees in Florida to 53 degrees in Minnesota. Finally, the temperature of the fuel in the supply line to the pump will affect the temperature of the fuel initially deposited into the vehicle.

State and local governments adopt and enforce weights and measures regulations, including those to ensure that retail fuel pumps accurately measure motor fuels. Unlike many other countries, the United States does not have a federal weights and measures regulatory agency, although two federal agencies help oversee the marketplace generally, and a third oversees aspects of the retail petroleum industry. Among other things, NIST cooperates with other entities, including state and local governments, to establish standard practices, codes, and specifications. The FTC enforces consumer protection laws, including laws related to unfair and deceptive practices in the marketplace. EPA and authorized states regulate underground storage tanks that store petroleum.[6] These regulations require a leak detection system on the underground storage tanks. None of these agencies has formally endorsed or opposed the implementation of automatic temperature compensation.

State and local governments develop regulations for weights and measures with input from NCWM and NIST. Established in 1905, NCWM is composed of state and local weights and measures officials, as well as related public and private sector members. A key goal of NCWM is to help ensure that consumers get the quantity of goods they pay for and that businesses sell the quantity that they advertise and intend to sell. NCWM helps ensure that uniform standards are applied to commercial transactions by developing regulatory standards for consideration by each jurisdiction, with technical, scientific, and administrative support provided

[5]The refining process "boils" crude oil to separate it into its various components. Gasoline is distilled from crude oil at temperatures ranging from 194 degrees F to 428 degrees F, while diesel is distilled at temperatures up to 698 degrees F.

[6]The underground storage tank regulations apply to underground tanks and pipes used to store or move petroleum and certain other hazardous chemicals.

by NIST. Membership in NCWM is open to all interested individuals, including regulatory officials, device manufacturers, and consumers; however, only regulatory officials may vote on the disposition of proposals under consideration by NCWM.

Most proposals for regulatory standards that come before NCWM originate in one of its regional weights and measures groups located throughout the nation or in one of its four standing committees, each of which focuses on a specialized area, such as laws and regulations. At each of NCWM's annual conferences, standing committees review the proposals submitted for consideration and hold open hearings to discuss them. Final reports containing the NCWM-approved model regulatory standards are presented in open forum to representatives and voted upon. Actions or subjects under consideration, but not proposed for voting, may be carried over for further consideration at a later time. NIST publishes NCWM's newly adopted model regulatory standards in handbooks. If a state chooses to adopt the model regulatory standards in state law or regulation, they will then have the effect of law in that state.

For over 30 years, NCWM has debated the pros and cons of compensating for temperature-induced changes in the volume of petroleum products, including gasoline and diesel. This debate is guided in part by NCWM's principles that any method of sale or measurement must provide accurate and adequate information about products so that purchasers can make price and quantity comparisons. In 2007, a standing committee recommended a proposal to allow, but not require, automatic temperature compensation at the retail level. NCWM did not reach consensus on the proposal, and the issue was deferred for further consideration. In 2008, a steering committee established by NCWM recommended a proposal to require automatic temperature compensation following a 10-year period during which retailers could decide when to purchase the equipment based on their business needs. According to the committee, this would allow the marketplace to determine when and whether to adjust retail sales for temperature. However, NCWM members did not reach consensus on the proposal, and the issue was deferred for further consideration. Also in 2007, the California legislature directed the state Energy Commission to study the costs and benefits of using automatic temperature compensation devices for retail sales, among other things. The commission is to complete its work by February 2009.

The Magnitude of Equipment and Education Costs of Adopting Automatic Temperature Compensation Is Unclear

Stakeholders said that implementing automatic temperature compensation for retail fuel sales would involve costs to purchase, install, and inspect new equipment on gasoline pumps, as well as costs to educate consumers about the change. Some stakeholders estimate the costs to purchase and install the temperature compensation devices would range from $1,300 to $3,000 per pump. To provide context for the estimates from stakeholders, we obtained information from two equipment manufacturers. These manufacturers said the costs can vary by the type of equipment. More specifically, the price of retrofit kits for electronic pumps ranges from $900 to $1,800, plus $200 to install them. Costs to retrofit mechanical pumps are higher: $2,000 to purchase and install a kit for one hose and $3,800 for a dual hose pump. The costs to individual retailers would vary, in part, depending on the number of pumps, the number of hoses per pump, and the mix of electronic and mechanical pumps that would need to be replaced or retrofitted. In addition, an equipment manufacturer said that maintenance costs for electronic pumps would be negligible over the useful life of a pump, 10 to 12 years. Some stakeholders noted that the magnitude of costs has not been estimated, in part, because certain data, such as the number of mechanical pumps still in use across the country, are not available. As a result, the costs to adopt automatic temperature compensation are not known.

Several stakeholders said costs to purchase and install temperature compensation equipment could also be affected by other factors. For example, under a phased implementation schedule, retailers could upgrade their equipment in the normal course of replacing equipment, whereas immediate implementation would require retailers to invest in the equipment without regard to their business plans or ability to pay immediately. Also, a small number of companies in North America manufacture new pumps equipped to automatically compensate for temperature or kits to retrofit existing pumps. Two stakeholders said that the costs to purchase and install the equipment could rise in the face of shortages of both equipment and skilled installers that would occur if implementation of automatic temperature compensation were to occur suddenly rather than over a longer period of time.

Estimates of the magnitude of inspection costs varied. A small number of state officials said that automatic temperature compensation could increase inspection time by 20 to 50 percent and might require the purchase of testing equipment. In contrast, officials in three other states said that inspection costs to adopt temperature compensation would not be significant, although they had not estimated the cost. In Missouri, state officials said legislation was introduced, but not enacted, to divide the state into regions, each of which would adopt a new reference

temperature based on its average ambient temperature. State officials reported that adoption of temperature compensation by changing reference temperatures would require increasing staff by six inspectors and one clerical person for a cost of about $1 million in the first 3 years.

No stakeholders have developed estimates of the costs to educate consumers when automatic temperature compensation is in use. However, costs would be incurred to provide disclosure on fuel pumps, customer receipts, and the street signs that show the retail price of fuel. A number of stakeholders noted that, if some retailers sold compensated fuels and others did not, consumers could be confused and might lack the ability to make informed value comparisons for their fuel purchases. According to some stakeholders, disclosure on pumps might be accomplished by adding the phrase "Volume corrected to 60 degrees F" to the face of the pump near the display of total gallons purchased. For customer receipts, printers could be programmed to add the same phrase. If automatic temperature compensation is in place throughout the nation, the need to disclose its use on pump signs might no longer be needed.

It Is Unclear Who Would Bear the Costs of Implementing Automatic Temperature Compensation

Stakeholders differ on whether consumers or a combination of retailers and consumers would bear the costs of implementing automatic temperature compensation. Specifically, many stakeholders, including state officials and industry representatives, said that the costs to purchase, install, and inspect compensation equipment would be passed on to consumers, generally through higher retail fuel prices, higher prices for nonfuel goods sold at retail fueling stations, or a combination of both. A few of these stakeholders said that retail prices must generally reflect the cost of goods sold or businesses will not remain in operation. However, since the information retailers use to make pricing decisions is proprietary in nature, it would be difficult to estimate how much prices would increase to cover the costs of implementing automatic temperature compensation. Some of these stakeholders also noted that differences in the cost of fuel and other goods sold could vary among retailers based on such factors as whether they owned or leased the land, the number of staff they employ, and whether the costs of inspections are paid directly by retailers or funded from tax receipts. However, one state official said that the ability of states to increase inspection fees may be limited by state statute.

Some stakeholders said the costs to implement automatic temperature compensation may result in disproportionate economic impacts on certain classes of retailers, such as small retailers and those in rural areas, that might be put out of business in the face of the investment to upgrade their

equipment. Retailers that are small or located in rural areas may dispense fewer gallons of fuel than larger retailers and, consequently, have fewer gallons from which to recover any costs associated with upgrading their equipment. A few stakeholders said an exemption for small retailers may be needed, such as an exemption based on the number of gallons dispensed. In contrast, another stakeholder said implementation that allowed retailers to make the decision of whether to add the devices to their equipment would eliminate the potential for disproportionate impacts.

However, other stakeholders, such as consumer groups, said that retailers and consumers would share in both the costs and the benefits of implementing temperature compensation. For example, one stakeholder noted that some retailers could use funds they receive from the major oil companies for remodeling to cover the cost of temperature compensation equipment. According to these stakeholders, consumers have already paid retailers for energy content they did not receive. That is, consumers generally buy fuel that is warmer than 60 degrees and has less energy content, according to these stakeholders. Such overpayments are greater in southern and western states than in other areas. Moreover, these stakeholders said consumers would benefit from greater transparency in fuel pricing, the ability to purchase fuel with more consistent energy content, and an enhanced ability to compare purchases from competing retailers because price differences would be based largely on differences in customer service or amenities such as clean rest rooms. One noted that retailers would also benefit because the automatic temperature compensation technology would allow retailers to manage inventory for both their deliveries and their sales of fuel on a temperature-compensated basis. Moreover, retailers could more easily identify fuel leaks by reconciling their inventory records to measurements of the fuel in their storage tanks. Specifically, if a measurement of stored fuel showed a retailer had less fuel on hand than it had sold, the difference could be the result of a leak.

Stakeholders also differed on the benefits of automatic temperature compensation. Many noted that temperature compensation provides a more accurate and replicable measurement method, but some expressed concern that the potential cost outweighed the benefit. Within the weights and measures community, support has been growing for the adoption of automatic temperature compensation standards, in part because of the improved accuracy and the availability of equipment that makes implementation more feasible than in the past. Several stakeholders noted that automatic temperature compensation brings equity to the marketplace and provides both consumers and retailers with comparable

information about their fuel purchases. Specifically, when retailers and consumers purchase temperature-compensated fuel, they each receive comparable products. According to two stakeholders, consumers currently cannot determine before or after a purchase the actual best price for a gallon of gas because they do not know the temperature of the fuel. Some stakeholders who thought the cost would outweigh the benefit said that the increased accuracy in measurement would not benefit consumers because fuel costs would increase as retailers recouped their investment in the compensation devices.

Stakeholders also held different opinions on whether automatic temperature compensation would ensure consistent energy content in each gallon of fuel. While temperature compensation adjusts for the impact of fuel temperature on the energy content of each gallon, it would not affect other factors that impact energy content, such as the use of fuel blends and additives. That is, multiple stakeholders said that the use of ethanol and other additives, as well as seasonal fuel blends, results in fuels that may vary in energy content by season or by retail outlet. More specifically, they noted other factors may affect the energy content of fuel, including the refining process itself and the crude oil used as the source for the gasoline. Others said automatic temperature compensation will ensure greater consistency in energy content and mileage per gallon. One stakeholder said that, as fuel prices increase, the issue of energy loss from the lack of temperature compensation will become more important, while another said that the use of blends could increase the significance of the effect of temperature on fuel in the future.

Stakeholders' views that various factors may affect fuel prices are consistent with our prior work on gasoline pricing.[7] Specifically, in a series of reports issued from 2000 through 2007, we concluded that higher gasoline prices resulted from a range of local and global factors, including higher crude oil prices, recent mergers and increased market concentration in the petroleum industry, the increased use of blended

[7]GAO, *Energy Markets: Increasing Globalization of Petroleum Products Markets, Tightening Refining Demand and Supply Balance, and Other Trends Have Implications for U.S. Energy Supply, Prices, and Price Volatility*, GAO-08-14 (Washington, D.C.: Dec. 20, 2007); GAO, *Gasoline Markets: Special Gasoline Blends Reduce Emissions and Improve Air Quality, but Complicate Supply and Contribute to Higher Prices*, GAO-05-421 (Washington, D.C.: June 17, 2005); GAO, *Energy Markets: Mergers and Many Other Factors Affect U.S. Gasoline Markets*, GAO-04-951T (Washington, D.C.: July 7, 2004); GAO, *Motor Fuels: Gasoline Prices in Oregon*, GAO-01-433R (Washington, D.C.: Feb. 23, 2001); and GAO, *Motor Fuels: California Gasoline Price Behavior*, GAO/RCED-00-121 (Washington, D.C.: Apr. 28, 2000).

fuels, the level of state gasoline taxes, and costs to transport gasoline from refineries to retailers. We also found in our work on the use of special gasoline blends that it can be difficult to establish a definitive causal link between factors and prices because only some of the many factors that may affect gasoline prices at various times are readily and consistently observable.

Regardless of their views, stakeholders based their opinions largely on professional judgment and general economic theory or assumptions about how the fuel market operates rather than on studies or other data. For example, one stakeholder commented that it was unreasonable to assume that retailers would absorb the costs to upgrade 14 or 16 pumps without trying to recoup those costs through the prices of retail goods they sell. However, none of the stakeholders based their views on studies of the impact of the costs on fuel or retail goods. Some stakeholders said that because the petroleum market is fiercely competitive, particularly in areas that sell high volumes of fuel, consumers already receive the lowest fuel price that retailers can offer, and one said that temperature is not likely to be a relevant factor in their pricing decisions. Because the fuel market is so competitive, one stakeholder said, retailers do not generate enough profit to cover the costs of temperature compensation equipment and so would pass the costs on to consumers. In contrast, other stakeholders said that retailers may already adjust their prices to account for the expansion and contraction of fuel, while still others questioned the benefit to consumers from investing in temperature-compensating devices in areas where the average ambient temperature is close to 60 degrees F.

The majority of stakeholders—including state officials, consumer and industry representatives, and fleet owners—said that a cost-benefit study such as the one under way in California would provide policymakers with important information. The California study will examine the costs for retailers to purchase and install appropriate equipment and calibrate it. In addition, the study will develop data on the costs to agencies to develop appropriate test procedures, acquire calibration equipment, and inspect the pumps at retail stations. Information on the costs and benefits was needed to make an informed decision on automatic temperature compensation, according to many stakeholders. A small number said they would wait to see the results of California's study before deciding whether to support or oppose the implementation of automatic temperature compensation. Moreover, some who oppose automatic temperature compensation said they would support it if a cost-benefit analysis showed a benefit for the consumer.

Governments That Have Adopted Automatic Temperature Compensation Did So Largely to Improve Purchasing Equity, and Those That Have Not Cited Concerns That the Costs Would Outweigh the Benefits

Governments that have adopted or permitted automatic temperature compensation, or are considering doing so, cited improved measurement accuracy and greater equity between retailers and consumers as reasons for making the change, whereas those governments that do not allow temperature compensation cited concerns that the costs would outweigh the benefits. Hawaii, Belgium, Canada, and the European Union (EU) have each adopted a policy on temperature compensation—mandatory in Hawaii and Belgium and permissive in the remaining jurisdictions. In addition, the United Kingdom is considering a national approach to temperature compensation, and Australia may do so again. Both countries debated the issue in the 1990s but did not adopt nationwide policies for retail fuel sales at that time.

Because retail motor fuel dispensers equipped with automatic temperature compensation devices were not readily available 26 years ago, Hawaii developed its own method to achieve temperature compensation for retail sales of fuel to provide purchasing equity for both the industry and the consumer, according to a state official. The method is based on test procedures that rely on both the temperature and density of the fuel. A 5-year study of the average temperature of fuel delivered to consumers in Hawaii found that the fuel temperature was approximately 80 degrees F. More specifically, Hawaiian weights and measures officials test retail pumps to ensure that they meet the state standard—to deliver the amount of fuel a 231 cubic inch gallon would occupy at 60 degrees F, or its expanded or contracted equivalent at any other temperature. In Hawaii, the expanded equivalent is about 234 cubic inches per gallon—to reflect the increased volume at the higher fuel temperature. Implementation was phased in over 1 year. A state official said retailers may apply for a variance from the state standard provided they can demonstrate that the temperature of the fuel they deliver to consumers in their location differs from 80 degrees F. According to a state official, temperature compensation is a matter of fairness and equity.

Belgium mandated temperature compensation for retail sales of fuel beginning in January 2008. Belgium adopted temperature compensation for retail sales, in part, because some retailers were artificially heating fuel, and the government sought greater consistency in the energy content of the fuel sold to consumers, according to a weights and measures official. After January 2008, any newly installed pumps must be equipped for temperature compensation and, by January 2015, all pumps must be equipped to dispense temperature-compensated fuel. A Belgian official told us that the 7-year transition period will allow retailers to make adjustments over time, in the normal course of their operations, thereby reducing the overall cost to implement temperature compensation. While

retailers will decide when to install temperature compensation equipment, they are prohibited from turning it off. That is, once the equipment is in place and dispensing temperature-compensated fuel, all hoses attached to the equipment must continue to dispense temperature-compensated fuel. To date, the Belgian government has not developed guidance for consumers or retailers, in part because the transition to temperature compensation has just begun, according to the official.

Canada has adopted a permissive policy on automatic temperature compensation for the retail sale of liquid petroleum products, such as gasoline, diesel, and home heating oil. Specifically, Canada established technical and other standards in the early 1990s that allowed retailers to sell temperature-compensated fuel, but it did not require them to do so. According to a Canadian official, Canada developed the standards largely for three reasons: advances in measurement technology had made temperature compensation equipment more readily available, automatic temperature compensation is thought to be a more equitable and accurate method of measuring fuel, and temperature compensation addresses retailers' concerns about inventory losses potentially due to temperature-related changes in volume. Today, over 90 percent of Canadian fuel retailers sell temperature-compensated fuel. Canada imposed policy controls on the use of temperature-compensated equipment to prevent practices that might harm consumers or businesses, and any change to pumps requires an inspection by government officials. For example, pumps with automatic temperature compensation devices must be operable and dispense temperature-compensated fuel at all times throughout the year. In addition, pumps equipped with the devices must have a sticker that says "Volume Corrected to 15 degrees C"[8] adjacent to the pump's visual and printed net quantity display. Retailers may elect to convert only selected pumps or product lines, provided that all pumps for the same grade or blend of fuel are converted and the compensation equipment is activated at the same time.[9] Because Canada's regulations are permissive rather than mandatory, retailers may choose to stop using compensation devices provided they obtain permission from Canadian weights and measures officials. Permission would not be granted if retailers wanted to only use automatic temperature compensation

[8]The reference standard of 15 degrees Celsius (C) is roughly equivalent to 60 degrees F.

[9]Canada also allows partial conversion to automatic temperature compensation based on "trade levels" that use different types of pumps, such as those mounted on vehicles or those that dispense fuel at high speed. In such cases, all pumps for a given trade level must be converted and activated at the same time.

seasonally when it was to their benefit, according to a Canadian official, who also said no retailers have sought to stop using the devices.

In addition, the EU currently permits member states to adopt temperature compensation, although fewer than 2 percent of retailers have installed the necessary equipment, according to an official with a European weights and measurement organization. This official said that making adoption possible, but not required, allows the market to make the decision when business owners decide it is in their interests to do so. As a result, implementation will occur gradually, thereby avoiding a "shock wave" from immediate mandatory implementation, according to the official. A shock wave would occur if retailers were required to purchase the equipment without regard to whether they had the funds to do so. The EU does not have a harmonized policy on temperature compensation, but, according to the official we interviewed, information on fuel temperature received by the retailer and dispensed to consumers would be important to the debate. However, the official also noted that retailers may, at their discretion, adjust prices to compensate for temperature-related changes in volume.

Currently, in Australia the states and territories require retailers to sell fuel on a compensated basis. However, by July 2010, responsibility for weights and measures regulation will shift from the states and territories to the federal government. According to an Australian official, the new national trade measurement legislation will replicate the current state and territory requirements for the sale of fuel. As part of the consultation process for developing new trade measurement regulations, comments on any aspect of trade measurement controls, such as temperature compensation, will be invited from all stakeholders, and the matter of temperature conversion of fuel sales at the retail level may well be raised.

Officials in the United Kingdom said they anticipate issuing a statement in the fall of 2008 that temperature compensation for retail fuel sales will be permitted nationwide but not mandated.

In the United States, officials in eight states that have laws or regulations prohibiting automatic temperature compensation largely said the decision should be based on an analysis of the costs and benefits, with some expressing concern that the anticipated costs would outweigh any benefit to consumers and fuel retailers. In some cases, these decisions were made more than 20 years ago, and the officials we interviewed had limited information about the reasons. More recently, Missouri and Texas considered state legislation to implement temperature compensation. In Missouri, where the average temperature of stored fuel is 62 degrees F,

officials said that consumers would be negatively affected if temperature compensation were adopted by changing the reference temperature because they would have to buy more temperature-adjusted gallons than uncompensated gallons to obtain the same amount of fuel. In addition, the state would need to add six inspectors and one clerical person at a cost of about $1 million in the first 3 years. Moreover, they said retailers would face significant expense to purchase the compensation equipment if temperature compensation were achieved by the use of compensation devices. Specifically, Missouri officials in 2006 estimated that 65 percent of the state's pumps could be retrofitted, and 35 percent would need to be replaced, at a cost of about $341 million. In Texas, officials have postponed further consideration of temperature compensation until a comprehensive nationwide cost-benefit analysis has been completed. In addition, officials in some states said that evidence of benefits to consumers from automatic temperature compensation could lead states to reconsider their current position.

Finally, governments have not formally studied the impact of their decisions to implement or not to implement automatic temperature compensation. Specifically, neither Hawaii nor Canada has studied the impact of temperature compensation, although officials reported it was not controversial and was generally well accepted by both consumers and the industry. In Belgium, temperature compensation has been implemented too recently to study its effects.

Concluding Observations

The weights and measures community has debated the costs and benefits of automatic temperature compensation for more than three decades with no resolution. The issues have not changed substantively, and both sides continue to passionately put forth their views. In general, supporters say that extending temperature compensation to the retail level could provide more transparency in fuel prices, while those who are opposed argue that upgrading existing equipment would be costly and pose potential economic hardship on retailers.

It remains unclear, however, what it would actually cost to implement automatic temperature compensation and whether consumers or businesses would end up paying those costs. Moreover, the two governments with the longest experience in temperature compensation of retail fuel sales (Hawaii and Canada) have not studied the effect of their policies. As a result, a policy debate is being played out without good information about the potential costs and benefits, and with both proponents and opponents basing their views on their professional judgment and their general understanding of economic theory.

Looking forward, there appears to be a real need for an objective analysis of the key issues stakeholders raise about costs and benefits, including the potential for higher costs to consumers and improved inventory management for retailers. Such a study would need to bring together petroleum-related scientific, engineering, and economic expertise. Absent such analyses, NCWM and state governments face potentially significant challenges to informing their decisions regarding automatic temperature compensation.

As agreed with your office, 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 of this report to the Chief, Weights and Measures Division, National Institute of Standards and Technology; stakeholders we interviewed; appropriate congressional committees; and other interested parties. We will also 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 maurerd@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made contributions to this report are listed in appendix II.

Sincerely yours,

David C. Maurer
Acting Director
Natural Resources and Environment

Appendix I: Scope and Methodology

In conducting our work on each of our objectives, we reviewed National Conference on Weights and Measures (NCWM) documents and congressional testimony and performed a literature search to identify relevant documents and stakeholders likely to have a view on the implementation of automatic temperature compensation. We used the individuals identified through our document review and literature search as a starting point for the sampling technique that we used to identify additional stakeholders. That is, we used an iterative process (often referred to as the "snowball sampling" technique) to identify other stakeholders and selected for interviews those who would provide us with a broad and balanced range of perspectives on temperature compensation of gasoline and diesel. We used a standard set of questions to interview each of these individuals to ensure we consistently discussed each aspect of automatic temperature compensation. We also asked open-ended questions to allow people to share their views on this issue. To develop the questions, we reviewed NCWM and National Institute of Standards and Technology (NIST) documents, as well as congressional testimony. We used content analysis to identify the main themes among responses.

We continued interviewing and soliciting names until we determined we had appropriate coverage from all the relevant stakeholder groups. During the course of our review, we interviewed officials from the following 15 organizations, listed alphabetically: American Automobile Association; American Petroleum Institute; American Trucking Association; Consumer Watchdog; Defense Energy Support Center; National Association of Convenience Store Owners; NATSO, an organization representing travel plaza and truck stop owners; Owner Operator Independent Drivers Association; Petroleum Marketing Association of America; Society of Independent Gasoline Marketers of America; Schneider National, Incorporated; Swift Transportation Incorporated; United Parcel Service; United States Postal Service; and Weights and Measures Consulting. In addition, we interviewed federal officials at NIST, the Environmental Protection Agency, and the Federal Trade Commission because these agencies help oversee the marketplace generally or oversee aspects of the retail petroleum industry. We also obtained information from two of the three manufacturers who produce equipment that allow for automatic temperature compensation at retail pumps.

We also contacted officials in 17 states that the literature suggested may have taken or considered specific steps to adopt or prohibit automatic temperature compensation. Some of these states had proposed legislation, were identified in a survey conducted by NIST on state practices, or were recommended by other officials. One state—California—is conducting a state-mandated cost-benefit analysis of automatic temperature

compensation. These 17 states included a mix of states that could be considered hot (5), cold (4), or neutral (7) based on NIST's analysis of temperature data for stored fuel. The 17th state was not included in NIST's analysis because of a lack of data. We interviewed officials in the following 17 states, listed alphabetically: Arizona, California, Florida, Hawaii, Iowa, Maine, Massachusetts, Minnesota, Missouri, Montana, Nebraska, New York, Oregon, Pennsylvania, South Dakota, Texas, and Wyoming.

Finally, we interviewed officials in Australia, Belgium, Canada, the Netherlands, and the United Kingdom because literature indicated they either had adopted or had considered implementing automatic temperature compensation, as well as officials at a European weights and measures organization.

We conducted our work from March 2008 to September 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for the information we present for each of our audit objectives.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

David C. Maurer, (202) 512-3841 or maurerd@gao.gov

Staff Acknowledgments

In addition to the individual named above, Cheryl Williams (Assistant Director), Cynthia Norris, and Henry Clay made key contributions to this report. Also contributing to this report were Pedro Almoguera, Nancy Crothers, and Cindy Gilbert.

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