Potential Supply Impacts of Removal of 1-Pound RVP Waiver

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Contacts

This report was prepared by the Office of Oil and Gas of the Energy Information Administration. General questions concerning the report may be directed to Mary J. Hutzler (202/586-2222, mhutzler@eia.doe.gov), Director, Office of Integrated Analysis and Forecasting, or Joanne Shore (202/586-4677, joanne.shore@eia.doe.gov), Team Leader, Petroleum Division

Potential Supply Impacts of Removal of 1-Pound RVP Waiver

On June 17, 2002, Senator Jeff Bingaman, Chairman of the Senate Committee on Energy and Natural Resources, requested (Appendix A) that the Energy Information Administration (EIA) provide analyses of eight factors related to the Senate-passed fuels provisions of H.R. 4, the Energy Policy Act of 2002. In response, EIA has prepared a series of analyses discussing the market impacts of each of these factors. This paper addresses factor number 7 of the Senator's request.

Because of the rapid delivery time requested by Sen. Bingaman, each requested factor related to the Senate-passed bill was analyzed separately, that is, without analyzing the interactions among the various provisions. In addition, assumptions about State actions, such as their implementation and timing of MTBE (methyl tertiary-butyl ether) bans, influence the results. Discussions about some of these interactions have been included in order to explain the interconnected nature of such issues.

EIA's projections are not statements of what will happen but what might happen, given known technologies, technological and demographic trends, and current laws and regulations. The EIA's *Annual Energy Outlook 2002 (AEO2002*) is used in these analyses to provide a policy-neutral Reference Case that can be used to analyze energy policy initiatives. EIA does not propose, advocate or speculate on future legislative or regulatory changes. Laws and regulations are assumed to remain as currently enacted or in force in the Reference Case; however, the impacts of emerging regulatory changes, when clearly defined, are reflected.

The analyses involve simplified representations of reality because of the complexity of both the issues examined and the environment in which they would occur. Projections are highly dependent on the data, methodologies, and assumptions used to develop them. Because many of the events that shape energy markets (including severe weather, technological breakthroughs, and geopolitical disruptions) are random and cannot be anticipated, energy market projections are subject to significant uncertainty. Further, future developments in technologies, demographics, and resources cannot be foreseen with any degree of certainty. These uncertainties are addressed through analysis of alternative cases in the *AEO2002*.

Introduction

This paper addresses the supply impacts that might occur if States choose not to allow the Federal 1-pound vapor pressure waiver when using 10-percent ethanol blends of gasoline. Price impacts were not examined because the schedule of this analysis did not allow sufficient time to research the costs and associated price implications. This paper provides background on the 1-pound waiver and how it can affect gasoline volumes. The volume issue is quantified at two levels. The first level looks at the volume effects of adding ethanol with and without the waiver on a per gallon basis, explaining why gasolines with different vapor pressures will experience different impacts. Second, using the per-gallon impacts of not using the waiver, two scenarios are used to explore U.S. supply impacts.

Description of the 1-Pound Waiver

As gasoline evaporates, volatile organic compounds (VOC's) enter the atmosphere and contribute to ozone formation. Gasoline's propensity to evaporate is measured by Reid vapor pressure (RVP).[1] In order to control VOC emissions, the Federal Clean Air Act Amendments of 1990 require that all gasoline be limited to an RVP maximum of 9.0 psi during the summer high ozone season, which the Environmental Protection Agency (EPA) established as running from June 1 to September 15. The Act also authorized the EPA to set more stringent standards for nonattainment areas. As a result, EPA limits areas designated as "high volatility non-attainment" to a maximum RVP of 7.8 psi during the high ozone season. Some States elected to require even more stringent restrictions to achieve local clean air goals, and require 7.2- and 7.0-psi gasolines.[2]

Today, the most commonly used conventional gasoline during the summer has an RVP of 9 psi, representing about 75 percent[3] of conventional gasoline consumption in the United States. About 20 percent of conventional gasoline is 7.8 psi, and the rest of the conventional market is 7.0-psi gasoline.[4]

As a part of the Clean Air Act Amendments, conventional gasoline containing 10 percent ethanol was allowed to exceed the Federal RVP maximums by 1 psi.[5] This issue is important during the summer months when low gasoline RVP is required and when gasoline demand is highest. In the winter, with higher RVP's being allowed, the impact is far less. It has been common practice in many areas using ethanol-blended gasoline to add 10 percent ethanol to finished conventional gasoline at blending terminals near consumers. (Appendix C in EIA's response to Questions 4, "Timing for the Startup of the Renewable Fuel Standard" describes how ethanol is handled in gasoline.) When 10

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[1] Because RVP measures the tendency of a material to evaporate, in the case of gasoline, it also measures the tendency to produce volatile organic compounds (VOC's). It is measured in pounds per square inch (psi), sometimes referred to as "pounds." Gasoline with a 9.0-psi RVP may be referred to as 9.0-pound gasoline, 9.0-RVP gasoline, or 9.0-psi gasoline.

[2] For an overview of Federal and State fuel requirements, EPA provides a summary in Appendix B of the following publication: Environmental Protection Agency, *Staff White Paper, Study of Unique Fuel Blends ("Boutique Fuels"), Effects on Fuel Supply and Distribution and Potential Improvements* (Washington, DC, October 2001) EPA420-P-01-004, http://www.epa.gov/otaq/regs/fuels/p01004.pdf

[3] EIA estimates are based on U.S. EPA gasoline-type spreadsheet of 6/21/01. These estimates are derived based on gasoline type (e.g., conventional, RFG, RVP level, etc.) on a county level, and allocating State gasoline consumption across counties based on relative population size.

[4] There is a small amount of 7.2-psi gasoline used in Illinois.

[5] Section 211(h)(4) of the Clean Air Act Amendments.

percent ethanol is added to 9.0-psi conventional gasoline, the RVP of the mixture will rise to about 10 psi. Without the 1-pound waiver, refiners would have to create a conventional gasoline blendstock for oxygenate blending (CBOB) with an RVP of about 8.0, which, when blended with the ethanol, increases to 9 psi.

Unlike 9.0-psi gasoline, 7.8 and 7.0-psi gasoline[6] experience more than a 1-psi increase in RVP when ethanol is added to produce a 10-percent ethanol blend based on experimental results (Table 1). Thus, even with the 1-pound waiver, a lower-RVP base gasoline blendstock must be created in areas using 7.8- or 7.0-psi gasoline to keep the RVP increase of the finished gasoline down to 1 psi after 10 percent ethanol is added.

Table 1. RVP Effects of Adding Ethanol to Gasoline

Finished Gasoline RVP Requirement	Approximate RVP Increase when Ethanol Added to Make 10% Blend	Base Gasoline RVP Adjustment Needed if 1 Pound Waiver Not Allowed
9.0	1.0	(1.1)
7.8	1.2	(1.3)
7.0	1.3	(1.4)

Sources: William J. Piel, "Oxygenate Flexibility for Future Fuels," Arco Chemical Company, paper presented at National Conference on Reformulated Gasoline and Clean Air act Implementation, Information Resources, Inc. Washington, DC, October 1991, American Petroleum Institute, *Alcohols and Ethers*, Publication 4261.

When the waiver is removed, all the different RVP gasolines shown in Table 1 must begin with a base gasoline that has a lower RVP to counter the "RVP boost" that occurs when the ethanol is added. The last column in Table 1 shows that the base gasoline prior to ethanol addition must have an RVP reduction that is slightly more than the "RVP boost" shown in the middle column. For example, adding ethanol to 9.0-psi gasoline prior to any adjustments raises the RVP by 1.0 psi, but without a waiver, the base gasoline must be reduced by 1.1 psi to bring the base blend down to 7.9 psi in order to keep the finished ethanol-blended product at 9 psi. This is because the RVP impact of adding ethanol increases as the RVP of the base gasoline blend declines.

Quantifying the Volume Impacts of the Waiver

This portion of the paper describes in more detail the effects of an RVP waiver on gasoline, estimates the volume impact on a per-gallon basis for different RVP gasolines, and translates that per gallon impact into a total U.S. supply impact by considering several simple scenarios.

Per Gallon Effect of an RVP Waiver

[6] The Federal waiver applies to Federal 7.8- and 9.0-RVP gasolines. If a State has opted to use 7.0 gasoline, it would have filed a plan with EPA that either allowed or did not allow the waiver. This analysis assumes 7.0-RVP gasoline may be using the waiver and thus may experience volume losses when the waiver is removed. We are aware of at least one 7.0-RVP area (Kansas City) in this situation.

For 9.0-psi conventional gasoline, the 1-pound RVP waiver allows gasohol suppliers to extend their gasoline volumes by more than 11 percent from what is produced at the refinery, since no changes need to be made to the gasoline before adding the ethanol. As described above, gasolines with RVP's lower than 9.0 psi experience more than a 1-psi increase when ethanol is added, so these fuels must have some high-RVP components removed to have a final blend with only 1 psi higher RVP (Table 1). With a waiver, the 7.8-RVP gasoline experiences a 10.3-percent increase in volume, and the 7.0-psi gasoline receives an 8.3-percent increase, both less than the 11.1-percent increase for 9.0-psi gasoline due to the need to remove some components (Table 2).

Table 2. Volume and Energy Effects to Adjust for RVP When Adding Ethanol

RVP	Volume Increase (Decrease) By Adding Ethanol to Make 10% Ethanol Blend		Energy Increase (Decrease) By Adding Ethanol to Make 10% Ethanol Blend	
	With RVP Waiver	Without RVP Waiver	With RVP Waiver	Without RVP Waiver
9.0	11.1%	7.5%	7.5%	4.5%
7.8	10.3%	2.2%	6.8%	-0.2%
7.0	8.3%	-0.9%	5.1%	-2.8%

Source: See Appendix B.

If the 1-pound waiver were not allowed, all conventional gasolines would have to be adjusted to balance the RVP. For 9.0-psi gasoline, both C_4's (e.g., butane)[7] and C_5's (e.g., pentane) would be removed to lower the RVP of the base gasoline blend. The volumes removed in this case represent more than 3 percent of the original 9.0-psi gasoline volume, so the net volume increase of adding the ethanol and removing the high-RVP components is only about 7.5 percent when not using the RVP waiver, compared to 11.1 percent with the waiver. Without the waiver, the 7.8-psi gasoline only gains 2.2 percent volume compared to 10.3 percent with the waiver, and 7.0-psi gasoline actually experiences a net loss in volume without the waiver.

From a national supply perspective, it is useful to note the energy impacts of adding ethanol to gasoline as well as the volume effects. Conventional gasoline without ethanol contains about 115,000 Btu in a gallon[8]. Ethanol contains 76,000 Btu in a gallon, or about two-thirds the energy of gasoline. Thus, when 90 gallons of conventional gasoline are extended to 100 gallons by adding 10 gallons of ethanol, the volume of the base 90 gallons has increased by about 11.1 percent, but the energy has only increased about 7.5

[7] Gasoline is a mixture of chemical compounds primarily made from hydrogen (H) and carbon (C). A compound containing only hydrogen and carbon is called a hydrocarbon. The size of these hydrocarbons is usually described by the number of carbon atoms which they contain, represented as C_4 or C_5, which means 4 carbon atoms or 5 carbon atoms respectively. Butane (C_4H_{10}) and butylenes (C_4H_8), for example, are both considered C_4s.

[8] Energy Information Administration, *Alternatives to Traditional Transportation Fuels, An Overview*, DOE/EIA-0585/O (Washington, DC, June, 1994), Table 22.

percent. Table 2 summarizes both the energy and the volume impacts of adding ethanol to gasoline with and without an RVP waiver.

The volume and energy impacts in Table 2 only represent the effects of removing light, high-RVP materials to counter ethanol's high blending RVP. When the fractions of components in gasoline are changed, the properties of gasoline also change. That is, refiners trying to maintain the properties of gasoline such as octane, driveability index (DI) and emissions, may find that the removal of C4s and C5s can require additional changes to the gasoline. These additional changes will be refinery specific and even batch specific. An examination of these issues indicates that maintaining most emission levels and engine performance, such as toxics and octane, would not require much, if any, additional change in volume from that shown in Table 2. For example, if C5's, clean hydrocarbons with low octane numbers, are removed, the octane of the remaining blend increases, as does the toxic level. As a result, refiners can reduce the octane of the reformate blending component. This is accomplished by running the reformer at lower severity, which not only produces a little more reformate volume, but also lowers the aromatics content in the reformate, helping to reduce toxics. The net result is a gasoline that has about the same octane and toxic levels as it did before the C5's were removed, and little volume changes beyond the volume lost from the C5 removal.

The impact of removing C5's on the DI poses a more difficult question. Consider an ethanol-blended gasoline that is being produced at the higher RVP with the waiver and that is close to the acceptable DI limit. When the waiver is removed, C5's need to be removed from the blend to lower the RVP, which also increases the DI. With the original blend being close to the DI limit, heavy, low-RVP materials may also have to be removed to lower the T90 and T50 levels and bring the DI back down to the limit. Batches subject to these changes would not benefit as much from the ethanol additions shown in Table 2 due to the need to remove even more base gasoline material than for RVP rebalancing alone. That is, the impact of the waiver removal on these gasolines would be greater than on gasolines in which the DI did not have to be adjusted. Estimating these impacts requires knowing the volumes of gasoline that run close to the DI limits, and knowing the variation in ethanol's impact on gasoline's distillation profile, which depends on the composition of the hydrocarbon base blend.[9]

To summarize, if the RVP waiver is used, all RVP blends will have a net increase in volume and energy with the addition of enough ethanol to make a 10 percent blend. Lower RVP gasolines experience less benefit because the addition of the ethanol raises the RVP more than 1 pound, requiring more high-RVP material to be removed. When the waiver is removed, 9.0-psi and 7.8-psi gasolines still have a net volume gain, but 7.0-psi gasoline has a net volume loss. The energy balance shows that, without the waiver, 9.0-psi gasoline has a net energy gain, 7.8-psi gasoline has about the same energy content, and 7.0-psi gasoline experiences a 3.5-percent energy loss. Further volume losses may be incurred by some refineries due to the need to readjust the DI downward by removing heavy components to counter the increase that occurs from removing the

[9] Gibbs, Lee, "Driveability and the Impact of Ethanol," Paper presented at Clean Fuels 2001 Conference, January 30-February 1, 2001, San Antonio, Texas.

light, high-RVP material.

These calculations are illustrative, and individual refiners can experience variances from these examples. Also, not all of the materials that are backed out of gasoline are necessarily lost to the gasoline pool. For example, if an individual refinery only produces a small amount of 7.8- or 7.0-psi gasoline, that refiner may be able to use the C_4's and C_5's being removed from the low-RVP gasoline in its 9.0-psi gasoline. However, they may not be able to make much use of these components during the high-demand summer months when lower gasoline RVP's are required, since the C4's and C5's increase RVP.

A Scenario to Illustrate Aggregate Impacts

In light of the renewable fuels standard being proposed, some States may be concerned about balancing the need to use ethanol in gasoline against the potential increase in emissions of VOC's that would accompany the 1-pound waiver. Without knowing which States might want to block use of the waiver, several scenarios are explored to provide an estimate of the U.S. supply effects of not allowing conventional gasoline to exceed RVP standards by 1 pound.

In developing a scenario, it is desirable to explore a case in which higher amounts of ethanol are being used in conventional gasoline[10] in order to explore whether or not removing the waiver might have a large impact on supply. The renewable fuel standard case[11] that is described in EIA's response to Question 2 represents such a scenario. The results of this case in 2012 are explored with and without the 1-pound waiver to determine its potential supply impacts.

By 2012, the proposed RFS requires that 5 billion gallons, or 325 thousand barrels per day, of ethanol must be used. The EIA analysis in response to Question 2 indicates that about half of the ethanol would be used in reformulated gasoline and E-85 blends. About 163 thousand barrels per day of ethanol would be blended into conventional gasoline.[12]. For the RVP waiver illustration, assume that all of the 2012 ethanol used in conventional gasoline is blended at 10 percent, and is, therefore, eligible for the waiver. That would imply that 1,630 thousand barrels per day of conventional gasoline is using 10 percent ethanol at that time.

The next assumption considers into which RVP levels of gasoline ethanol may be added. The largest economic incentive for using ethanol is in 9.0-psi gasoline, since this gasoline requires no change before adding ethanol under the waiver, and achieves the greatest

[10] Recall that RFG cannot use the 1-pound waiver.
[11] EIA National Energy Modeling Sytem run Rfaeo02A.d041002b
[12] In 2001, about 85 thousand barrels per day of ethanol were blended into conventional gasoline. This figure is estimated based on an assumption that the Midwest is where all of the ethanol-blended RFG was used in 2001. The Midwest used 277 thousand barrels per day of RFG in 2001, which translates to 28 thousand barrels per day of ethanol, if 10 percent blends are assumed. With a U.S. total of 113 thousand barrels per day of ethanol used in gasoline in 2001, this estimate implies about 85 thousand gallons per day were used in conventional gasoline.

volume and energy increase both with and without a waiver compared to the 7.0- and 7.8-psi gasolines. Thus, the first scenario assumes all of the gasoline blended with ethanol has an RVP of 9.0 psi.[13]

A second scenario was developed that allowed some use of the low-RVP gasolines (7.8 and 7.0 psi). Some low-RVP gasoline is blended with ethanol today and uses the 1-pound waiver. Use of the waiver in areas where a low-RVP gasoline is required has occurred in regions that moved from 9.0-psi ethanol blended gasoline using the waiver to a lower RVP ethanol-blended gasoline (e.g., 7.8 psi) using the waiver, effectively moving the region's RVP down from 10 psi to 8.8 psi. Thus, the region receives a 1.2-psi reduction. To give consideration to low-RVP gasoline impacts on removing the 1-pound waiver, a scenario is considered in which the 1,630 thousand barrels per day of ethanol-blended gasoline is spread among 7.0-, 7.8-, and 9.0-psi gasolines according to the shares of such RVP blends seen today in total conventional gasoline. The economic disincentive to use ethanol in low-RVP gasolines indicates this scenario will likely over-estimate the effect of low-RVP gasolines on the supply situation with and without the 1-pound waiver. Table 3 summarizes the different RVP volumes in both scenarios.

Table 3. Volumes of 10-Percent Ethanol Blends of Conventional Gasoline Projected for 2012
(Thousand Barrels Per Day)

	Scenario 1: All 9.0 psi RVP	Scenario 2: 2001 RVP Shares
All RVP's Combined	1,636	1,636
9.0 psi	1,636	1,227
7.8 psi	0	327
7.0 psi	0	82

Source: Energy Information Administration

Applying the volume gains (or losses) on a per-gallon basis from Table 2 to the volumes in Scenario 1, we see from Table 4 that if all volumes used the waiver, the ethanol adds about 163 thousand barrels per day of fuel. If none of the gasoline were allowed to use the waiver, removal of the additional material to balance the RVP would provide a smaller net gain of 114 thousand barrels per day. Thus, the loss of the waiver would result in a loss of almost 50 thousand barrels per day of conventional gasoline. On an energy equivalent basis (Table 5), the impact of the waiver is about the same.

[13] This scenario has over 7 million barrels per day of conventional gasoline being consumed. If the share of 9.0-psi gasoline is the same in 2012 as today (75 percent), about 5,250 thousand barrels per day of conventional gasoline would be 9.0 psi. Thus, the assumption that 1,630 thousand barrels per day might be 9.0 psi is not out of line with 9.0-psi gasoline that might be used in 2012.

Table 4. 9.0-psi Gasoline Volume Gains When Adding Ethanol To Make 10% Blends
(Thousand Barrels Per Day)

RVP	With Waiver	No Waiver	Difference
9.0	163.3	114.0	49.3
7.8	0.0	0.0	0.0
7.0	0.0	0.0	0.0
Total	**163.3**	**114.0**	**49.3**

Source: Energy Information Administration

Table 5. 9.0-psi Gasoline Energy Gains When Adding Ethanol To Make 10% Blends
(Thousand Barrels Per Day Gasoline Equivalent)

RVP	With Waiver	No Waiver	Difference
9.0	114.5	70.4	44.0
7.8	0.0	0.0	0.0
7.0	0.0	0.0	0.0
Total	**114.5**	**70.4**	**44.0**

Source: Energy Information Administration

The second scenario assumes that some volumes of 7.0- and 7.8-psi gasoline are being blended with ethanol and would be using the waiver. As demonstrated in Table 2, these low-RVP gasolines experience greater volume losses than 9.0-psi gasoline when adding ethanol. As a result, Table 6 shows that Scenario 2, with the waiver, has less total volume gain (159 versus 163) than Scenario 1 when ethanol is added. The next columns in Tables 4 and 6 show that removing the waiver has a much greater effect on Scenario 2 than Scenario 1, with Scenario 1 showing a gain of 114 thousand barrels per day, which is 22 thousand barrels higher than Scenario 2 at 92 thousand barrels per day. The net effect of not using the waiver in Scenario 2 is a loss of 68 thousand barrels per day, compared with 49 thousand barrels per day in Scenario 1. The energy impact is similar, as shown in Table 7.

Table 6. Varying RVP Gasoline Volume Gains When Adding Ethanol to Make 10% Blend
(Thousand Barrels Per Day)

RVP	With Waiver	No Waiver	Difference
9.0	122.4	85.5	37.0
7.8	30.6	6.9	23.7
7.0	6.3	-0.7	7.0
Total	**159.3**	**91.7**	**67.6**

Source: Energy Information Administration

Table 7. Varying RVP Gasoline Energy Gains When Adding Ethanol to Make 10% Blend (Thousand Barrels Per Day Gasoline Equivalent)

RVP	With Waiver	No Waiver	Difference
9.0	85.8	52.8	33.0
7.8	21.0	-0.5	21.6
7.0	4.0	-2.4	6.4
Total	**110.9**	**49.9**	**60.9**

Source: Energy Information Administration

The uncertainties surrounding these estimates are large. The two scenarios ignore the potential further losses due to gasoline adjustments that might have to be made to re-balance properties other than RVP. The cases assume that all volumes of ethanol-blended gasoline would not be allowed to use the 1-pound waiver, when in reality, the waiver would likely continue for some volumes. That is, some States would choose to continue using the waiver.

Supply Shifts Implied by Waiver Removal

The scenarios describe a world in 2012 in which, if the waiver is being used, renewable fuels would be adding about 160 MB/D to conventional gasoline supply in 2012 – a volume that is almost double its use in conventional gasoline today. If the waiver is not used under the extreme scenarios described above, ethanol would be adding only 90-115 thousand barrels per day to net supply.

While not using the waiver would reduce renewable fuel contribution to supply in 2012, refiners or importers should be able to easily produce the difference (50-70 thousand barrels per day) since conventional gasoline is not expected to face the critical supply issues that reformulated gasoline is facing. Today, U.S. refiners produce over 8.5 million barrels per day of gasoline during the summer, and by 2012, refiners are projected to be producing well over 9.0 million barrels per day on an annual basis. If they had to add the high scenario amounts derived in the preceding discussion of about 50-100 thousand barrels per day to their output of conventional gasoline, it would represent an increase of 0.5-1.0 percent. The gradual growth in conventional gasoline volumes from today to 2012 should allow refiners time to adjust. Imports of conventional gasoline also can contribute to the additional supply needed. While gasoline imports of reformulated gasoline may be in short supply, conventional gasoline should be more readily available. Europe, for example, is likely to continue to have excess conventional gasoline available for export.[14]

[14] Energy Information Administration paper presented at the 2001 Annual Meeting of the National Petroleum Council -- http://www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2002/npra/index.html

Even if the DI uncertainties further affect the volumes, the most that would be offset is the 163 thousand barrels per day of ethanol contribution. From a total supply perspective, an additional 163 thousand barrels per day of conventional gasoline should be able to be produced or imported in 2012 without too much difficulty.

While in aggregate the 1-pound waiver does not seem to pose serious supply constraints, this analysis was not able to investigate local supply issues that could arise. If local supply constraints should arise, the RFS does provide refineries with some flexibility mechanisms. Under the proposed RFS, refiners that have trouble producing ethanol-blended conventional gasoline due to DI effects could purchase credits. Also, the proposed legislation requires EPA to review the supply implications of any request for exemption from the waiver, which should help to avoid supply problems.

Conclusion

In conclusion, there are two volume impacts of removing the waiver. The first is the impact on total gasoline volumes. In 2012, for example, conventional gasoline is projected to contain about 163 thousand barrels per day of ethanol. Ignoring the lower energy content of ethanol, if removal of the waiver countered the entire addition of ethanol in 2012, 163 thousand barrels per day of additional conventional supply would be needed. U.S. refiners could make up the difference since conventional gasoline supply does not face the same production challenges as RFG. Imports could also contribute. The analysis above indicated that, if the waiver were removed, less than half of this amount would need to be replaced.

While the loss of potential volume can be made up, any loss of volume is an issue due to the lack of available refining capacity in the United States, and due to pending State and Federal regulations that impact supply, some of which are discussed in EIA's responses to other questions requested by Sen. Bingaman. Also, timing of transitions to waiver removal situations can be important to supply since many refiners may have to make modest investments to be able to accommodate the lower RVP gasolines needed without the waiver. The proposed legislation requires the EPA Administrator to review the supply implications of any State asking to be exempt from the waiver, which provides for protection against the many uncertainties inherent in this and other analyses performed at this time.

The second effect on volume of not using the waiver is from the perspective of the contribution renewable fuels are making to conventional gasoline. Here, the removal of the waiver has a large impact. The removal of the waiver shown in this analysis would reduce renewables contribution to conventional gasoline by 30 or 40 percent. To improve on these estimates, more analysis is needed to determine the potential impacts of adjustments to meet DI requirements and to better understand which States or regions might want not to use the waiver.

Appendix A

Request from Committee and EIA Interim Response

Request from Committee

United States Senate

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510-6150

ENERGY.SENATE.GOV

June 17, 2002

Dr. Mary Hutzler
Acting Administrator
Energy Information Administration
1000 Independence Avenue SW
Washington, DC 20585

Dear Acting Administrator Hutzler:

The Senate passed version of H.R.4 contains a number of provisions affecting fuels markets that require additional analysis prior to final conference decisions. First, the oxygenate requirement for RFG would be eliminated and the states would be allowed to ban the use of MTBE beginning in 2004, a national phase out would follow. Also beginning in 2004, a certain portion of all gasoline sold in the U.S. will have to be from "renewable fuels", this requirement will affect all refiners and gasoline markets. The combination of these two factors alone has the potential to significantly impact US motor fuels markets.

As we all know too well, every previous significant change to fuel formulations has resulted in severe price volatility in various US motor fuels markets. Each time, the Committee on Energy & Natural Resources has held hearings to review the problems in an effort to avoid or at least mitigate future recurrence of such dislocations. The Energy Information Administration (EIA) has also investigated and reported on these various transitions. We should be able to apply what we have learned from these past market transition experiences to ease the implementation of these various changes that will start to take effect in 2004.

Therefore, I am requesting that the EIA analyze the potential market implications of the Senate-passed fuels provisions in H.R.4 combined with known and anticipated regulatory changes. This should include specific analysis of the following factors:

1. The expected volumetric shortfall in fuels supplies with an effective MTBE ban in 2004;
2. Actual renewable fuels production capacity, supply, and constraints and the effect on price;
3. Inter-regional transportation issues and associated costs for renewable fuels;

4. The potential effect of operating the mandate on a fiscal year, (i.e. beginning in October) vs. calendar year basis;
5. The environmental impact of the simultaneous implementation of the low sulfur and Mobile Source Air Toxic (MSAT) gasoline regulations and a national ethanol mandate;
6. The impact on gasoline price and supply when many additional ozone non-attainment areas come under the new 8-hour ozone standard;
7. The potential cost and supply impacts associated with individual states seeking to protect air quality through the removal of the one-pound vapor pressure waiver for gasoline blended with ethanol;
8. The potential effect/role of implementation of a national menu of fuels to address the proliferation of boutique fuels.

As earlier requests have noted, it would be helpful to have this study completed as soon as possible. Should you have any questions, regarding this request, please contact Jennifer Michael at the Committee, at (202)224-7143. I thank you in advance for your assistance.

Sincerely,

Jeff Bingaman
Chairman, Senate Committee on
Energy & Natural Resources

cc: file

EIA Interim Response **June 21, 2002**

The Honorable Jeff Bingaman
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510-6150

Dear Mr. Chairman:

This responds to your request of June 17, 2002, for information on potential impacts that the Senate-passed version of H.R. 4 might have on petroleum markets. Because we cannot provide quantitative answers to all of your questions within the time limits that would be useful for your deliberations, we will provide some qualitative responses. In the next 6 to 8 weeks, we plan to address your questions as follows:

1) **Expected volume shortfall in fuel supplies with an effective methyl tertiary butyl ether (MTBE) ban in 2004**: We will use a simple volume-balancing approach to quantify the volume loss of MTBE, the various means of making up that reduction, the potential volumes associated with those means, and the hurdles to exercising those supply responses.

2) **Actual renewable fuels production capacity, supply, and constraints and the effect on price**: We will look at current capacity, planned additions, and capacity needed beyond that already announced to provide required ethanol supply between now and 2007. Consideration will be given to needed ethanol supply both with and without an MTBE ban, since our prior analysis of MTBE bans showed an increase in demand for ethanol above the Renewable Fuel Standard (RFS) in earlier years. We will also discuss potential impediments and price impacts.

3) **Inter-regional transportation issues and associated costs for renewable fuels**: Because the Energy Information Administration has not done an independent study on this issue and because of your time constraints, we will respond to this request by summarizing recent studies on the transportation issues associated with distribution and storage of ethanol.

4) **The potential effect of operating the mandate on a fiscal year (i.e., beginning in October) vs. calendar year basis**: It is our understanding from your staff that this question is intended to address the startup of an RFS program and whether delaying the start date from January to October 2004 (thereby starting the program after the high-demand summer season) would reduce the potential for price volatility. We will provide a qualitative answer to this issue after investigating the operating issues in more detail.

5) **The environmental impact of the simultaneous implementation of the low sulfur and Mobile Source Air Toxic (MSAT) gasoline regulations and a national ethanol mandate:** We understand that this question is meant to explore whether spreading the start dates further apart for the low sulfur programs and ethanol mandate could reduce the potential for supply dislocations and associated price volatility. Because MSAT is currently in place, we will explore adjusting the start dates for low sulfur gasoline, low sulfur diesel, and the ethanol mandate. As in question 4, we will provide a qualitative answer to this issue after investigating the operating issues in more detail.

6) **The impact on gasoline price and supply when many additional ozone non-attainment areas come under the new 8-hour ozone standard**: Once we have obtained guidance on the assumptions for the desired reformulated gasoline (RFG) requirement scenarios from your staff, we will analyze the implications of adding the new RFG regions.

7) **The potential cost and supply impacts associated with individual states seeking to protect air quality through the removal of the one-pound vapor pressure waiver for gasoline blended with ethanol:** The impact of the waiver is on summer gasoline. Because we do not have the modeling ability to analyze seasonal variations in gasoline specifications, we will estimate the potential volume of supply that would be backed out of the summer gasoline pool to meet the lower Reid Vapor Pressure (RVP) standard and assess the refiners' abilities to make up that supply. We will also qualitatively discuss other aspects of the issue that may affect supply.

8) **The potential effect/role of implementation of a national menu of fuels to address the proliferation of boutique fuels**: The boutique fuel issue is complex, and no one to our knowledge currently has the capability to quantitatively analyze the price impacts of reducing the number of fuels. However, we can assist the Committee in understanding what dimensions need to be considered when proposals are raised to reduce the number of fuels. We will do this by defining the source of the boutique fuel problem and describing the major market dimensions of these fuels that increase the potential for price volatility.

We will provide you with answers to as many of these questions as possible by the end of July with the remainder completed in August. Please call me on 202/586-4361 should you need further information regarding this request.

Sincerely,

Mary J. Hutzler
Acting Administrator
Energy Information Administration

cc: The Honorable Frank Murkowski
Ranking Minority Member

Appendix B. Data Used in Volume and Energy Calculations

The calculations used to estimate the per-gallon volume and energy changes are summarized in Tables B1-B5. Tables B1 and B2 summarize the volume impacts and display the energy content information used to derive the energy effects shown in Table 2. The energy calculations assumed all denaturant was gasoline and adjusted the base gasoline volume for the loss of C_4 and C_5 energy content where appropriate.

Tables B3-B5 display the calculations that derived the volumes shown in Table B1. The volume calculations use the RVP changes shown in Table 1. They also assume, based on industry information, the mix of C_4's and C_5's that must be removed to achieve lower RVP's. Generally C_4's would be removed first, but eventually, C_5's must also be removed. The Chevron RVP-blending index[15] was used to estimate the volumes of C_4's and C_5's that need to be removed in order to achieve lower-RVP base gasolines. The calculations were compared against other empirical vapor pressures for use in blending calculations, and the results were similar.

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[15] The Chevron blending index (RVPI) is calculated as $RVPI = RVP^{1.25}$, and is tabulated in James H. Gary, *Petroleum Refining, Technology and Economics*, (New York, NY: Marcel Dekker, Inc., 1975) p. 166.

Table B1. Summary of Volume and Energy Impacts of Conventional Gasoline Being Blended with Ethanol

	C_4 Removed	C_5 Removed	CG Used	Denaturant	Ethanol Added	Total	Percent Change from 9.0 RVP No Ethanol
9.0 RVP No Ethanol			1.0000			**1.0000**	
9.0 with Waiver							
Volume (1)			1.0000	0.0053	0.1058	**1.1111**	**11.1**
Energy Equivalent			1.0000	0.0053	0.0699	**1.0752**	**7.5**
9.0 Without Waiver							
Volume (1)	0.0165	0.0159	0.9676	0.0051	0.1024	**1.0751**	**7.5**
Energy Equivalent			0.9722	0.0051	0.0677	**1.0450**	**4.5**
7.8 with Waiver							
Volume	0.0024	0.0045	0.9931	0.0053	0.1051	**1.1035**	**10.3**
Energy Equivalent			0.9940	0.0053	0.0695	**1.0687**	**6.9**
7.8 without Waiver							
Volume (1)	0.0064	0.0739	0.9197	0.0049	0.0973	**1.0219**	**2.2**
Energy Equivalent			0.9292	0.0049	0.0643	**0.9984**	**-0.2**
7.0 With Waiver							
Volume (1)	0	0.0253	0.9747	0.0052	0.1031	**1.0830**	**8.3**
Energy Equivalent			0.9776	0.0052	0.0682	**1.0509**	**5.1**
7.0 Without Waiver							
Volume (1)	0	0.1078	0.8922	0.0047	0.0944	**0.9914**	**-0.9**
Energy Equivalent			0.9044	0.0047	0.0624	**0.9716**	**-2.8**

Note: CG – Conventional Gasoline. Volumes are measured relative to a volume of “1.0” for gasoline before ethanol is added. Volumes of gasoline are reduced as high-RVP material is removed to counter the RVP increase of adding ethanol. The calculations of these volumes are shown in tables B3 through B5. Denaturant is assumed to be gasoline.
Source: Energy Information Administration

The energy impacts were derived using the following heating values in Table B2.

Table B2. Lower Heating Values

Component	Gasoline Energy Equivalent	Heating Value Btu per Gallon
Gasoline	1.0000	115,000
Ethanol	0.6609	76,000
C4's	0.8301	95,500
C5's	0.8867	102,000
Source: Energy Information Administration, *Alternatives to Traditional Transportation Fuels, An Overview*, (Washington DC: June 1984), Table 22.		

Table B3. Volume Adjustments for 9.0 psi Gasoline When Adding Ethanol With and Without the 1-Pound RVP Waiver

		Percent C4/(C4+C5) Removed	Percent C5/(C4+C5) Removed	Original Gasoline RVP	C4's Removed	C5's Removed	Base Gasoline Requirement
9.0 RVP GASO	RVP (psi)			9.0000	52.0000	17.0000	9.0000
w/ Waiver	Blending RVP Index (1)			15.6000	138.0000	34.5000	15.6000
	Assumed C4/C5 Proportions Removed (2)	0	0.0				
	Volume Fractions				0.0000	0.0000	1.0000
	Volume x Blending RVP			0.0000	0.0000	0.0000	15.6000
	10% Blend Ethanol Volume						0.1111
	Ethanol Volume Excl Denaturant (3)						0.1058
9.0 RVP GASO	RVP (psi)			9.0000	52.0000	17.0000	7.9000
w/out Waiver	Blending RVP Index (1)			15.6000	138.0000	34.5000	13.2000
	Assumed C4/C5 Proportions Removed (2)	51	49.0				
	Volume Fractions			1.0000	0.0165	0.0159	0.9676
	Volume x Blending RVP			15.6000	2.2800	0.5476	12.7724
	10% Blend Ethanol Volume						0.1075
	Ethanol Volume Excl Denaturant (3)						0.1024

Note: (1) Blending indices are used to estimate the final RVP of a mixture of components in order to approximate the non-linear behavior of RVP.
(2) Assumed relative amounts of high-RPV material being extracted to balance the RVP in order to determine the volumes of C4's and C5's that must be removed.
(3) Ethanol denaturant is assumed to be gasoline. See http://www.hartenergynetwork.com/motorfuels/federal/doc/reg/atf/summary.htm
Source: Energy Information Administration

Table B4. Volume Adjustments for 7.8 psi Gasoline When Adding Ethanol With and Without the 1-Pound RVP Waiver

		Percent C4/(C4+C5) Removed	Percent C5/(C4+C5) Removed	Original Gasoline RVP	C4's Removed	C5's Removed	Base Gasoline Requirement
7.8 RVP GASO	RVP (psi)			7.8000	52.0000	17.0000	7.6000
w/ Waiver	Blending RVP Index (1)			13.0000	138.0000	34.5000	12.6000
	Assumed C4/C5 Proportions Removed (2)	35	65				
	Volume Fractions			1.0000	0.0024	0.0045	0.9931
	Volume x Blending RVP			13.0000	0.3324	0.1543	12.5133
	10% Blend Ethanol Volume						0.1103
	Ethanol Volume Excl Denaturant (3)						0.1051
7.8 RVP GASO	RVP (psi)			7.8000	52.0000	17.0000	6.5000
Without Waiver	Blending RVP Index (1)			13.0000	138.0000	34.5000	10.4000
	Assumed C4/C5 Proportions Removed (2)	8	92				
	Volume Fractions			1.0000	0.0064	0.0739	0.9197
	Volume x Blending RVP			13.0000	0.8865	2.5486	9.5649
	10% Blend Ethanol Volume						0.1022
	Ethanol Volume Excl Denaturant (3)						0.0973

Note: (1) Blending indices are used to estimate the final RVP of a mixture of components in order to approximate the non-linear behavior of RVP.
(2) Assumed relative amounts of high-RPV material being extracted to balance the RVP in order to determine the volumes of C4's and C5's that must be removed.
(3) Ethanol denaturant is assumed to be gasoline. See http://www.hartenergynetwork.com/motorfuels/federal/doc/reg/atf/summary.htm
Source: Energy Information Administration

Table B5. Volume Adjustments for 7.0 psi Gasoline When Adding Ethanol With and Without the 1-Pound RVP Waiver

		Percent C4/(C4+C5) Removed	Percent C5/(C4+C5) Removed	Original Gasoline RVP	C4's Removed	C5's Removed	Base Gasoline Requirement
7.0 RVP GASO	RVP (psi)			7.0000	52.0000	17.0000	6.7000
w/ Waiver	Blending RVP Index (1)			11.4000	138.0000	34.5000	10.8000
	Assumed C4/C5 Proportions Removed (2)	0	100.0				
	Volume Fractions			1.0000	0.0000	0.0253	0.9747
	Volume x Blending RVP			11.4000	0.0000	0.8734	10.5266
	10% Blend Ethanol Volume						0.1083
	Ethanol Volume Excl Denaturant (3)	0.9524					0.1031
7.0 RVP GASO	RVP (psi)			7.0000	52.0000	17.0000	5.6000
Without Waiver	Blending RVP Index (1)			11.4000	138.0000	34.5000	8.6100
	Assumed C4/C5 Proportions Removed (2)	0	100.0				
	Volume Fractions			1.0000	0.0000	0.1078	0.8922
	Volume x Blending RVP			11.4000	0.0000	3.7178	7.6822
	10% Blend Ethanol Volume						0.0991
	Ethanol Volume Excl Denaturant (3)						0.0944

Note: (1) Blending indices are used to estimate the final RVP of a mixture of components in order to approximate the non-linear behavior of RVP.
(2) Assumed relative amounts of high-RPV material being extracted to balance the RVP in order to determine the volumes of C4's and C5's that must be removed.
(3) Ethanol denaturant is assumed to be gasoline. See http://www.hartenergynetwork.com/motorfuels/federal/doc/reg/atf/summary.htm
Source: Energy Information Administration