EFFECTS OF

AN RFS ON U.S. ENERGY SAVINGS,

NATIONAL COSTS OF GASOLINE PRODUCTION, AND

THE REGIONAL PATTERN OF ETHANOL USE

Prepared for

American Petroleum Institute

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OVERVIEW

The U.S. Congress is considering RFS proposals requiring progressively increasing volumes of ethanol in U.S. gasoline, with total ethanol use reaching 5, 6, or 8 billion gallons per year (bgy) in 2012. The major effects of increasing ethanol use from the AEO 2005[1] projection for 2012 (3.8 bgy) to the proposed RFS volumes would include:

- **Energy Savings**. An RFS would reduce fossil energy use by about 25–30 thousand coeb/day at 5 bgy, 30–45 thousand coeb/day at 6 bgy, and 60–80 thousand coeb/day at 8 bgy – with corresponding reductions in U.S. fossil fuel imports.[2] These reductions in fossil fuel imports would be less than *0.5%* of projected net U.S. oil and natural gas imports of 17 million coeb/day in 2012[3], or less than 2 months of typical recent *growth* in oil and natural gas imports.

- **Cost of Energy and Import Savings**. The energy and import savings from an RFS would cost about $90-$130/coeb at 5 bgy, $95-$150/coeb at 6 bgy, and $110-190/coeb at 8 bgy, *over and above the price of crude oil*.

- **National Cost**. An RFS would increase the cost of producing gasoline by about $0.9 billion/year at 5 bgy, $1.9 billion/year at 6 bgy, and $3.8 billion/year at 8 bgy. These costs would fall on U.S. consumers (through higher costs of gasoline production) and taxpayers (through increased subsidies for ethanol production).

- **Regional Ethanol Use**. The additional ethanol use mandated by an RFS would be concentrated in the Midwest, to minimize costs, but would extend into the East Coast and Gulf Coast as well. Ethanol use in all of these regions would increase with increasing RFS mandate volume. In general, gasoline producers in the Midwest and East Coast would be net sellers of ethanol credits and gasoline producers in other regions, along with foreign suppliers, would be net buyers of ethanol credits.

The findings reported here come from a detailed technical and economic analysis, originally conducted and recently updated by MathPro Inc., of the effects of an RFS on the refining economics of U.S. gasoline supply.

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1 *Annual Energy Outlook 2005*; U.S. Department of Energy/Energy Information Administration; Table 17

2 **Coeb** stands for crude oil equivalent barrel, *a unit of energy equal to the average energy content in a barrel of crude oil. Energy flows are often expressed in coeb to place flows of oil, natural gas, coal, and other energy sources on a consistent basis.*

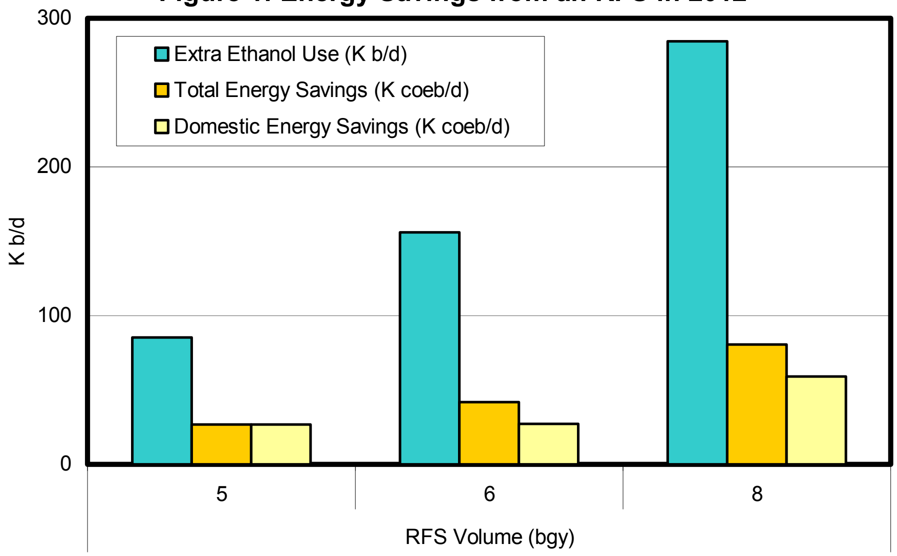
3 AEO 2005, Tables 11 and 13

EFFECTS ON FOSSIL ENERGY SAVINGS, IMPORTS, AND ENERGY USE

An RFS would provide savings in U.S. fossil energy use ranging (in energy-equivalent terms) from about **25–30 thousand coeb/day** at 5 bgy, **30–45 thousand coeb/day** at 6 bgy, and **60–80 thousand coeb/day** at 8 bgy – with corresponding reductions in U.S. fossil fuel imports (combined imports of crude oil, petroleum products, and natural gas). (**Figure 1**)

The indicated total energy savings at all RFS levels would lead to import reductions amounting to less than *0.5%* of projected net U.S. oil and natural gas imports of **17 million coeb/day** in 2012[4], or less than 2 months of typical recent *growth* in oil and natural gas imports.

Figure 1: Energy Savings from an RFS in 2012



The lower numbers in each range are the *net domestic savings* in fossil energy use resulting from the indicated level of ethanol use; the higher number in each range is the *total savings* in fossil energy use, including both domestic *and* foreign producers of U.S. gasoline.

> Both U.S. producers and foreign producers of U.S. gasoline would increase their production of gasoline for ethanol blending in response to an RFS. To the extent foreign refineries do so, some the total energy savings produced by an RFS would actually be realized in the countries of origin instead of in the U.S. On the other hand, the costs of ethanol production would be incurred in the U.S., regardless of where the base gasoline blend was produced.

The savings in fossil fuel use and the corresponding import displacements due to additional ethanol use result from a complex set of interactions among the various energy effects of additional ethanol use.

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[4] AEO 2005, Tables 11 and 13

- The total energy input to corn ethanol production – mainly from oil and natural gas – is about 75% of ethanol's energy content.

- Ethanol has energy content (and fuel economy) about 66% that of gasoline. Hence, adding a gallon of ethanol to the gasoline pool displaces about 0.66 gallon of gasoline.

- Putting ethanol into low-emission gasolines – such as RFG and low-RVP gasoline – requires taking out some other gasoline components, in order to maintain volatility standards.

- Energy use for transporting ethanol via rail, truck, or barge to gasoline blending sites would increase.

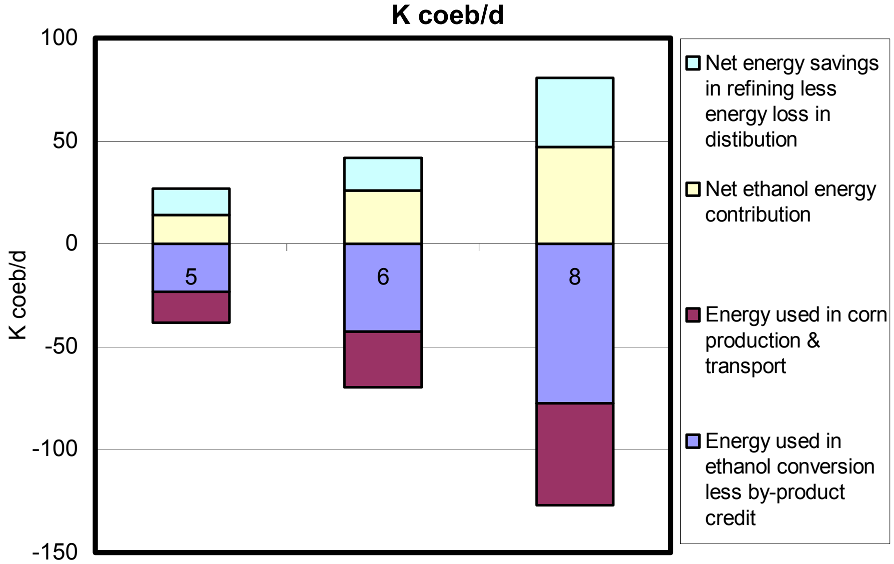
- Refineries would accommodate additional ethanol volumes in U.S. gasoline by reducing crude oil and other inputs, refined product outputs, and energy use.

- The natural gas needed for additional ethanol production would be imported from sources outside North America – the marginal sources of supply for both oil and natural gas.

Because our analysis accounts for these and other energy effects of increased ethanol use, the *total* energy savings shown in Figure 1 exceed ethanol's net energy value alone.

Figure 2 illustrates the net effect on total fossil energy use of the various energy effects of ethanol use.

Figure 2: Effects on Energy Use of an RFS in 2012, K coeb/d



As Figure 2 indicates, the total energy savings of additional ethanol use is the sum of (1) *the net energy contribution of ethanol* (its total energy content minus the fossil energy inputs to produce it) plus (2) *the net energy savings in refining and distribution* from reducing crude oil and other inputs, refined product outputs, and refinery energy use.

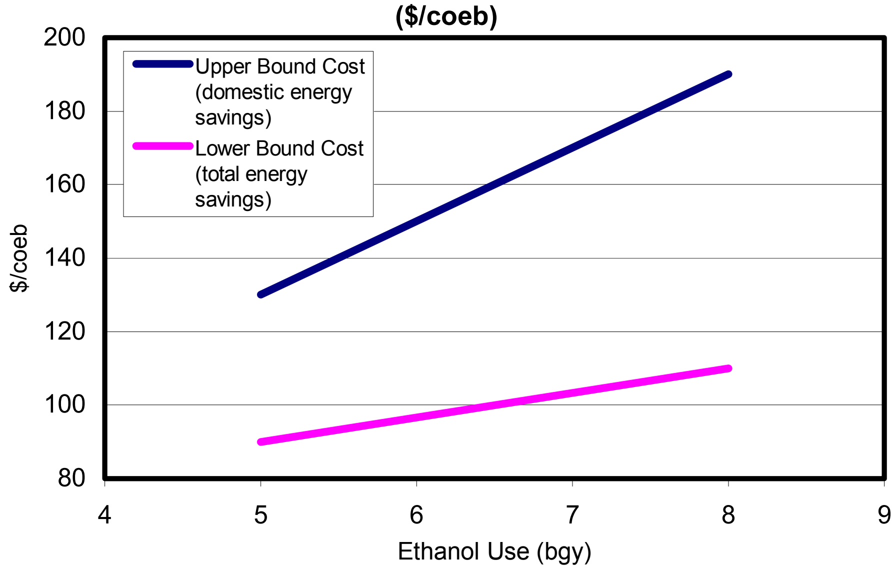
The net energy contribution of ethanol changes in direct proportion to ethanol volume. But, the net energy savings in refining and distribution can change in relative terms as ethanol volume increases, because the distribution of ethanol use by region and gasoline type and other technical factors can change with ethanol volume.

At all mandate volumes, some of the net energy savings in the refining industry will accrue to foreign suppliers of gasoline for ethanol blending, accounting for the difference between total energy savings and domestic energy savings.

COST OF ENERGY SAVINGS

The energy and import savings shown in Figure 1 would cost about **$90-$130/coeb** at 5 bgy, **$95-$150/coeb** at 6 bgy, and **$110-190/coeb** at 8 bgy, *over and above the price of crude oil.* (**Figure 3**)

Figure 3: Average Cost of RFS Energy Savings in 2012 ($/coeb)



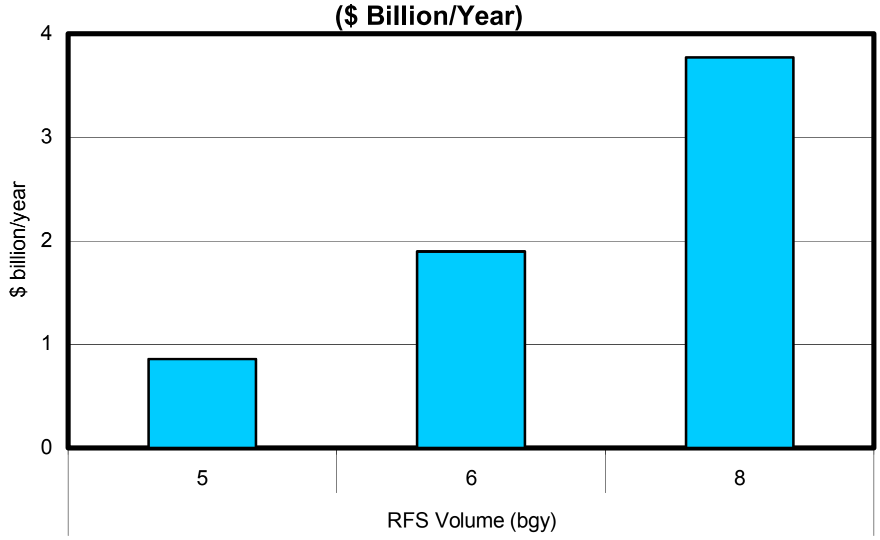
The higher cost number in each range applies to the *net U.S. savings* in fossil energy use resulting from the indicated level of ethanol use; the lower number to the *total savings* in fossil energy use, including those accruing to both domestic and foreign producers of U.S. gasoline.

NATIONAL COSTS INCURRED IN GASOLINE PRODUCTION

The additional ethanol use mandated by an RFS would increase the *national costs* of gasoline production by about **$0.9 billion/year** at 5 bgy, **$1.9 billion/year** at 6 bgy, and **$3.8 billion/year** at 8 bgy. (**Figure 4**)

The national cost of an RFS is the *net loss* in U.S. economic resources resulting from the additional ethanol use mandated by the RFS: the amount by which the full cost of meeting U.S. gasoline demand with an RFS exceeded the full cost without an RFS. These costs would fall on U.S. consumers (through higher costs of gasoline production) and taxpayers (through increased subsidies for ethanol production).

Figure 4: National Costs of an RFS in 2012 ($ Billion/Year)

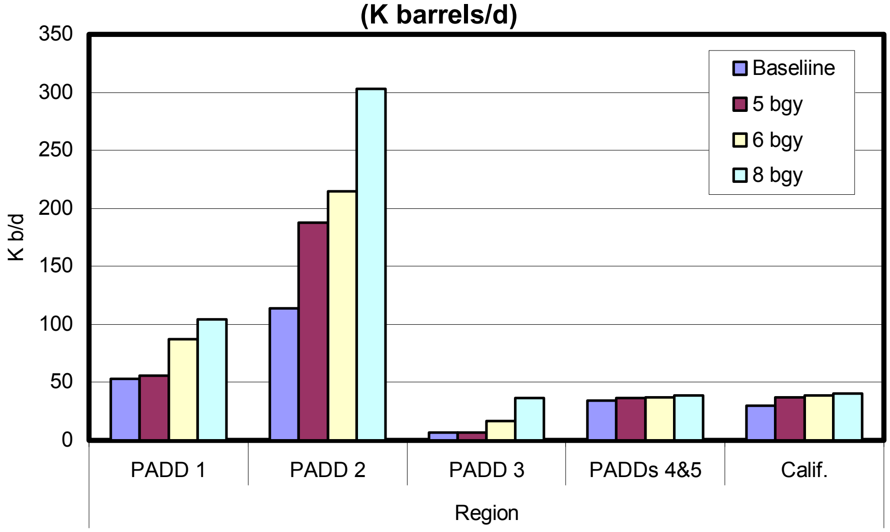


Ethanol use raises the cost of producing gasoline because ethanol's *value* as a gasoline component is less than the full *cost* of producing and delivering it. Furthermore, ethanol's refining value decreases and its production cost increases as the volume of ethanol use increases. Hence, the larger the RFS volume, the larger the national cost in terms of both total dollars per year and ¢/gal of ethanol.

Regional Pattern of Ethanol Use

The additional ethanol use mandated by an RFS would be concentrated in the Midwest, to minimize costs, but would extend into the East Coast and Gulf Coast as well. Ethanol use in all of these regions would increase with increasing RFS mandate volume. (**Figure 5**)

Figure 5: Regional Ethanol Use with an RFS in 2012 (K barrels/d)



- **PADD 1** (New England, Mid-Atlantic, Southeast) – Local ethanol use would increase by **3 K bbl/day** at 5 bgy, **35 K bbl/day** at 6 bgy, and **50 K bbl/day** at 8 bgy. The additional ethanol would be blended into conventional gasoline and federal RFG, using base blends produced in PADD 1 refineries as well as in PADD 3 and foreign refineries.

- **PADD 2** (Midwest) – Local ethanol use would increase by **75 K bbl/day** at 5 bgy, **100 K bbl/day** at 6 bgy, and **190 K bbl/day** at 8 bgy. The additional ethanol would be blended into conventional gasoline, federal RFG, and even low-RVP gasolines, using base blends produced in PADD 2 refineries as well as in PADD 3 and PADD 1 refineries.

- **PADD 3** (Gulf Coast) – Local ethanol use would increase by a negligible amount at 5 bgy, **10 K bbl/day** at 6 bgy, and **30 K bbl/day** at 8 bgy. The additional ethanol would be blended into conventional gasolines. PADD 3 refineries would produce progressively increasing volumes of base blends for ethanol blending in PADDs 1 and 2.

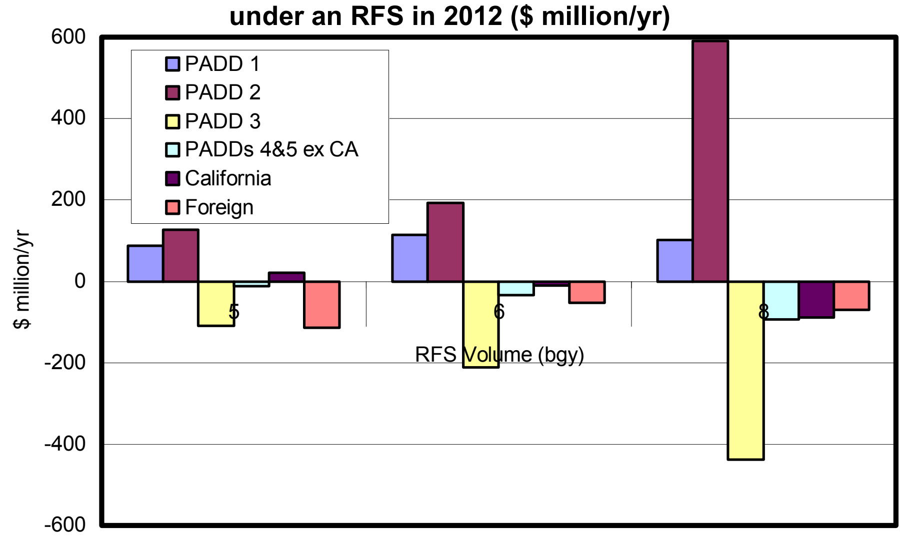
- **PADDs 4& 5,** ex California (Mountain States and Northwest) and **California** – Local ethanol use would increase by only small volumes under all RFS levels.

INTER-REGIONAL CREDIT TRADING

Every gasoline producer would have to comply with an RFS, either through physical ethanol blending or the use of *ethanol credits*. The credit-trading program associated with an RFS would allow producers who use more than their pro-rata share of ethanol to earn excess ethanol credits that could be sold; producers who use less than their pro-rata share would buy ethanol credits to make up the shortfall. A credit trading system reduces the national cost of an RFS, because it concentrates ethanol use where it is least costly.

As Figure 5 suggests, all RFS mandate volumes would lead to excess ethanol credits in PADDs 1 and 2, which would be sold to buyers in the rest of the country. This sale and purchase of ethanol credits would lead to inter-regional monetary flows, and those inter-regional monetary flows would increase with increasing RFS mandate volume.[5] (**Figure 6**)

Figure 6: Revenue Flows from Ethanol Credit Trading under an RFS in 2012 ($ million/yr)



PADD 2 could realize net revenues from trading in the range of about **$125 million per year** at 5 bgy to about **$600 million/year at 8 bgy**. PADD 1 could realize net revenues from trading in the range of **$90-$110 million per year**. PADD 3, PADDs 4 & 5 (ex California), California, and foreign gasoline suppliers would be net credit buyers and so would experience revenue outflows from trading. PADD 3 could experience the largest revenue outflows, ranging from about **$110 million per year** at 5 bgy to about **$440 million per year** at 8 bgy.

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5 Little is known about how an ethanol credit-trading program would work. To estimate the revenue flows shown in Figure 6, we assumed that (1) surplus credits would be earned in the regions producing gasoline for ethanol blending and (2) the value of ethanol credit would reflect the difference between ethanol's purchase cost and its refining value as a gasoline component.

BASIS FOR THE FINDINGS REPORTED HERE

The findings reported here come from a detailed technical and economic analysis, originally conducted and recently updated by MathPro Inc., of the effects of an RFS on the refining economics of U.S. gasoline supply. The analysis

- Reflects baseline ethanol use of 3.8 bgy, corresponding to DoE's projection of ethanol use in 2012, without an RFS.
- Used (1) Department of Agriculture estimates of the net energy inputs to ethanol production (net of by-product credits); (2) Department of Energy forecasts of crude oil and natural gas prices, U.S. gasoline demand, and domestic gasoline production; and (3) Global Insight forecasts of corn prices and by-product values at different levels of ethanol use.
- Assumed continuation of (1) the federal excise tax credit for ethanol blending (currently at 51¢/gal) after its scheduled expiration in 2010, (2) the 1 psi RVP waiver for ethanol-blended conventional gasoline and (in the Midwest) low-RVP gasoline, (3) existing state tax subsidy programs for ethanol blending (e.g., Illinois, Iowa), (4) existing state ethanol mandates (e.g., Minnesota, Arizona (winter)), and (5) existing state credits for ethanol production.

All prices are in 2003 US$. All ethanol volumes are annual averages.

ADDENDUM

to

EFFECTS OF

AN RFS ON U.S. ENERGY SAVINGS,

NATIONAL COSTS OF GASOLINE PRODUCTION, AND

THE REGIONAL PATTERN OF ETHANOL USE

Prepared for

American Petroleum Institute

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INTRODUCTION

Recently, MathPro Inc. submitted to the American Petroleum Institute an analysis of the primary energy effects of proposed Renewable Fuels Standards (RFS) being considered in Congress. Those RFS proposals call for progressively increasing volumes of ethanol in U.S. gasoline, with total ethanol use reaching 5, 6, or 8 billion gallons per year (bgy) in 2012.

This addendum extends the analysis to additional RFS proposals, calling for ethanol use of 10 and 12 bgy in 2012. It has the same organization and format as the original report, but differs from it in terms of the ethanol mandate volumes considered.

OVERVIEW

The major effects of increasing ethanol use from the AEO 2005[1] projection for 2012 (3.8 bgy) to the proposed RFS volumes of 10 and 12 bgy would include:

- **Energy Savings**. An RFS would reduce fossil energy use by about 75-130 thousand coeb/day at 10 bgy and 85-170 thousand coeb/day at 12 bgy – with corresponding reductions in U.S. fossil fuel imports.[2] The lower number in each range is the *net domestic savings* in fossil energy use resulting from the indicated level of ethanol use; the higher number in each range is the *total savings* in fossil energy use, including both domestic *and* foreign producers of U.S. gasoline.

  These reductions in fossil fuel imports would be less than *1%* of projected net U.S. oil and natural gas imports of 17 million coeb/day in 2012.[3]

- **Cost of Energy and Import Savings**. The energy and import savings from an RFS would cost about \$120-\$230/coeb at 10 bgy and \$130-\$270/coeb at 12 bgy.

- **National Cost**. An RFS would increase the cost of producing gasoline by about \$6 billion/year at 10 bgy and \$8.5 billion/year at 12 bgy. These costs would fall on U.S. consumers (through higher costs of gasoline production) and taxpayers (through increased subsidies for ethanol production).

- **Regional Ethanol Use**. The additional ethanol use mandated by an RFS would be concentrated in the Midwest, to minimize costs, but would extend into the East Coast and Gulf Coast as well. Ethanol use in all of these regions would increase with increasing RFS

1 *Annual Energy Outlook 2005*; U.S. Department of Energy/Energy Information Administration; Table 17

2 **Coeb** stands for crude oil equivalent barrel, *a unit of energy equal to the average energy content in a barrel of crude oil.* Energy flows are often expressed in coeb to place flows of oil, natural gas, coal, and other energy sources on a consistent basis.

3 AEO 2005, Tables 11 and 13

mandate volume. In general, at the higher mandate volumes considered, gasoline producers in the Midwest, along with foreign suppliers, would be net sellers of ethanol credits; gasoline producers in other regions would be net buyers of ethanol credits.

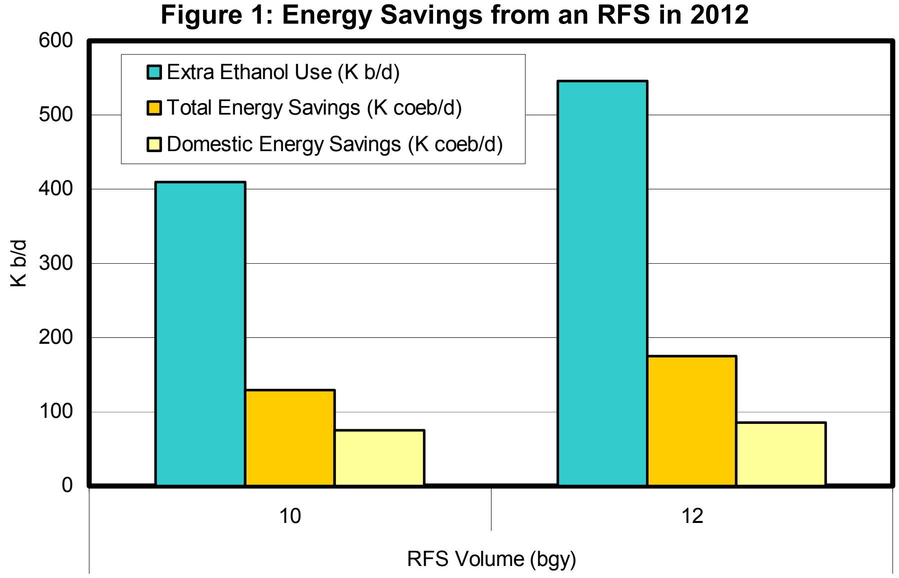
The findings reported here come from a detailed technical and economic analysis, originally conducted and recently updated by MathPro Inc., of the effects of an RFS on the refining economics of U.S. gasoline supply.

EFFECTS ON FOSSIL ENERGY SAVINGS, IMPORTS, AND ENERGY USE

An RFS would provide savings in U.S. fossil energy use ranging (in energy-equivalent terms) from about **75–130 thousand coeb/day** at 10 bgy and **85–170 thousand coeb/day** at 12 bgy – with corresponding reductions in U.S. fossil fuel imports (combined imports of crude oil, petroleum products, and natural gas). (**Figure 1**)

The indicated total energy savings at these RFS levels would lead to import reductions amounting to less than *1%* of projected net U.S. oil and natural gas imports of **17 million coeb/day** in 2012.

Figure 1: Energy Savings from an RFS in 2012



The lower number in each range is the *net domestic savings* in fossil energy use resulting from the indicated level of ethanol use; the higher number in each range is the *total savings* in fossil energy use, including both domestic *and* foreign producers of U.S. gasoline.

> Both U.S. producers and foreign producers of U.S. gasoline would increase their production of gasoline base blends for ethanol blending in response to an RFS. To the extent foreign refineries do so, some the total energy savings produced by an RFS would actually be

realized in the countries of origin instead of in the U.S. On the other hand, the costs of ethanol production – including energy inputs – would be incurred in the U.S., regardless of where the gasoline base blend was produced.

The savings in fossil fuel use and the corresponding import displacements due to additional ethanol use result from a complex set of interactions among the various energy effects of additional ethanol use.

- The total energy input to corn ethanol production – mainly from oil and natural gas – is about 70%–75% of ethanol's energy content.[4]

- Ethanol has energy content (and fuel economy) about 66% that of gasoline. Hence, adding a gallon of ethanol to the gasoline pool displaces about 0.66 gallon of gasoline.

- Putting ethanol into low-emission gasolines – such as RFG and low-RVP gasoline – requires taking out some other gasoline components, in order to maintain volatility standards.

- Energy use for transporting ethanol via rail, truck, or barge to gasoline blending sites would increase.

- Refineries would accommodate additional ethanol volumes in U.S. gasoline by reducing crude oil and other inputs, refined product outputs, and energy use.

- The natural gas needed for additional ethanol production would be imported from sources outside North America – the marginal sources of supply for both oil and natural gas.

Because our analysis accounts for these and other energy effects of increased ethanol use, the *total* energy savings shown in Figure 1 exceed ethanol's net energy value alone.

Figure 2 illustrates the net effect on total fossil energy use of the various energy effects of ethanol use.

The total energy savings of additional ethanol use – indicated by the portion of the bar above the zero line in Figure 2 – is the sum of (1) *the net energy contribution of ethanol* (its total energy content minus the fossil energy inputs to produce it) plus (2) *the net of energy savings in refining* from reducing crude oil and other inputs, refined product outputs, and refinery energy use and *energy loss in distribution* of increasing volumes of ethanol to end-use sites out of the Midwest.[5]

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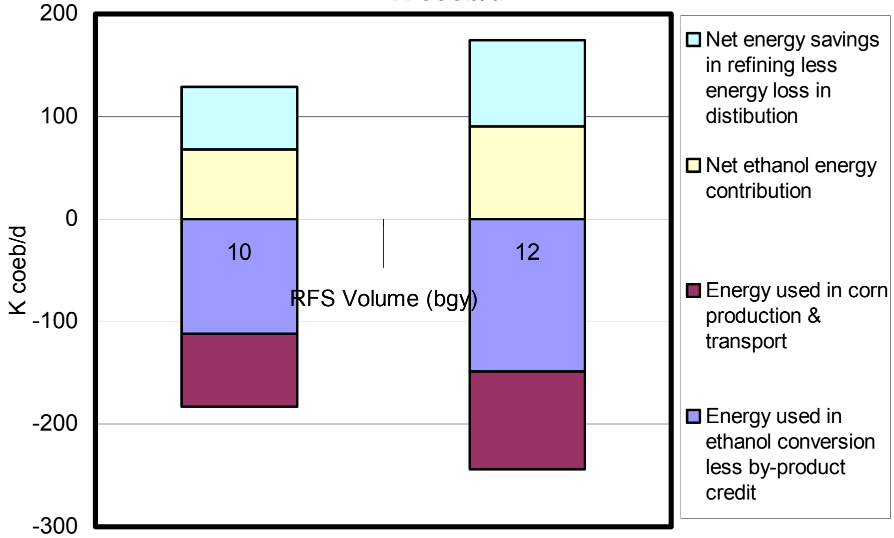
4 *The Energy Balance of Corn Ethanol: An Update*; U.S. Department of Agriculture; AER-814; July 2002. The previous analysis (5, 6, and 8 bgy mandate volumes) used a value of 73%, equal to the DoA estimate for the volume-weighted average of all ethanol plants – wet mill and dry mill – adjusted for the energy use in ethanol distribution, which we estimated independently. The current analysis (10 bgy and 12 bgy mandate volumes) used a value of 71%, equal to the DoA estimate for dry mill plants only (again adjusted for energy use in ethanol distribution), reflecting the assumption that dry milling is the process of choice for new ethanol plants.

5 In Figure 2, the part of the bar above the zero line for a given mandate volume, indicating the total energy savings of additional ethanol use, corresponds directly to the middle bar in Figure 1, for the same mandate volume.

Figure 2: Effects on Energy Use of an RFS in 2012, K coeb/d



The net energy contribution of ethanol changes in direct proportion to ethanol volume. But, the net energy savings in refining and distribution can change in relative terms as ethanol volume increases, because the distribution of ethanol use by region and gasoline type and other technical factors can change with ethanol volume.

At all mandate volumes, some of the net energy savings in the refining industry will accrue to foreign suppliers of gasoline for ethanol blending, accounting for the difference between total energy savings and domestic energy savings.

COST OF ENERGY SAVINGS

The energy savings shown in Figure 1 would cost about **\$120-\$230/coeb** at 10 bgy and **\$130-\$270/coeb** at 12 bgy, *net after realizing the savings in the U.S. cost of oil imports*.[6] (**Figure 3**)

The higher cost number at each mandate volume applies to the *net U.S. savings* in fossil energy use resulting from the indicated level of ethanol use; the lower number to the *total savings* in

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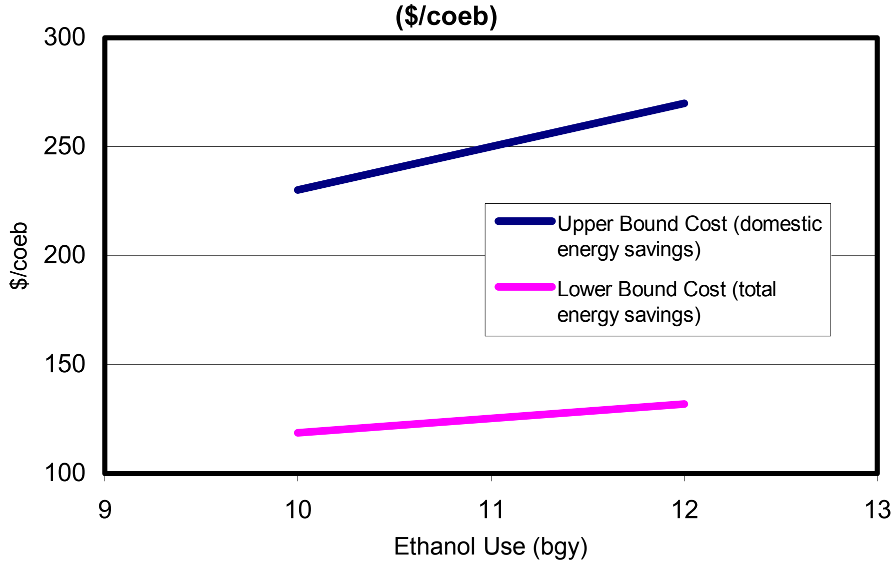
[6] A simple numerical example involving two refining scenarios may clarify the meaning of this statement. In the Baseline scenario, assume that the refining sector uses 100 barrels/day of crude oil, meets gasoline demand (with some ethanol use), and incurs total costs of \$10,000/day, including the purchase cost of the 100 barrels of crude. In the Ethanol Mandate scenario, assume that the refining sector uses 99 barrels/day of crude, meets gasoline demand (with additional ethanol use), and incurs total costs of \$10,200/day, including the purchase cost of the 99 barrels of crude and the full production cost of the additional ethanol. The savings in crude oil resulting from the ethanol mandate comes at a cost \$200 per barrel, net after realizing the saving in the purchase cost of crude oil.

fossil energy use, including those accruing to both domestic and foreign producers of U.S. gasoline.

Figure 3: Average Cost of RFS Energy Savings in 2012 ($/coeb)



These costs are the total national cost of the additional ethanol use at a given mandate volume (discussed below) divided by the estimated savings in fossil energy use, expressed in coeb.

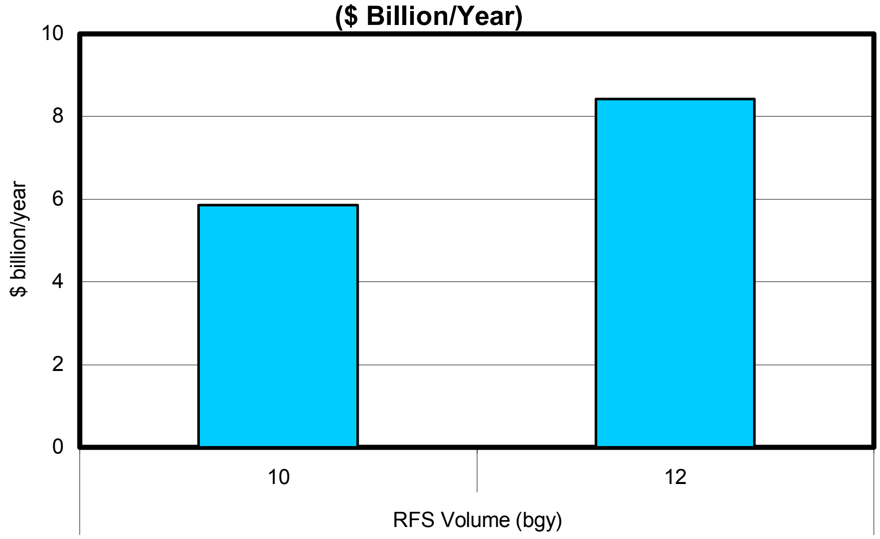
NATIONAL COSTS INCURRED IN GASOLINE PRODUCTION

The additional ethanol use mandated by an RFS would increase the *national costs* of gasoline production by about **$6 billion/year** at 10 bgy and **$8.5 billion/year** at 12 bgy. (**Figure 4**)

The national cost of an RFS is the *net loss* in U.S. economic resources resulting from the additional ethanol use mandated by the RFS: the amount by which the full cost of meeting U.S. gasoline demand with an RFS exceeded the full cost without an RFS. These costs would fall on U.S. consumers (through higher costs of gasoline production) and taxpayers (through increased subsidies for ethanol production).

Ethanol use raises the cost of producing gasoline because ethanol's *value* as a gasoline component is less than the full *cost* of producing and delivering it. Furthermore, ethanol's refining value decreases and its production cost increases as the volume of ethanol use increases. Hence, the larger the RFS volume, the larger the national cost in terms of both total dollars per year and ¢/gal of ethanol.

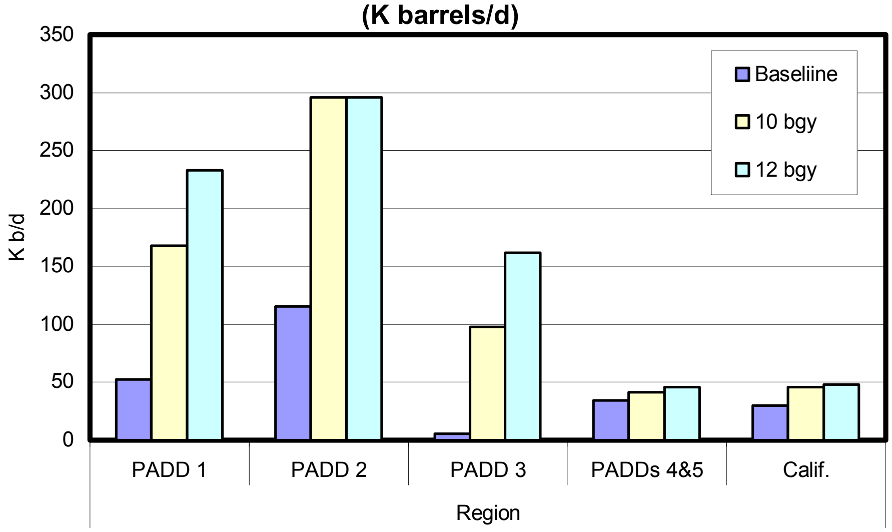
Figure 4: National Costs of an RFS in 2012
($ Billion/Year)



Regional Pattern of Ethanol Use

The additional ethanol use mandated by an RFS would be concentrated in the Midwest, to minimize costs, but would extend into the East Coast and Gulf Coast as well. At both 10 bgy and 12 bgy, ethanol use in PADD 2 would be at its maximum. Ethanol use in all other regions would increase with increasing RFS mandate volume. (**Figure 5**)

Figure 5: Regional Ethanol Use with an RFS in 2012
(K barrels/d)



- **PADD 1** (New England, Mid-Atlantic, Southeast) – Local ethanol use would increase by **120 K bbl/day** at 10 bgy and **180 K bbl/day** at 12 bgy, relative to the baseline. The additional ethanol would be blended into conventional gasoline and federal RFG, using base blends produced in PADD 1 refineries as well as in PADD 3 and foreign refineries.

- **PADD 2** (Midwest) – Local ethanol use would increase by **180 K bbl/day** at both 10 bgy and 12 bgy. At these mandate volumes, all gasoline sold in PADD 2 would be ethanol-blended.

- **PADD 3** (Gulf Coast) – Local ethanol use would increase by **90 K bbl/day** at 10 bgy and **160 K bbl/day** at 12 bgy. The additional ethanol would be blended into conventional gasolines. PADD 3 refineries also would produce progressively increasing volumes of base blends for ethanol blending in PADDs 1 and 2.

- **PADDs 4& 5,** ex California (Mountain States and Northwest) and **California** – Local ethanol use would increase by about **20 K bbl/day** at 10 bgy and **30 K bbl/day** at 12 bgy.

INTER-REGIONAL CREDIT TRADING

Every gasoline producer would have to comply with an RFS, either through physical ethanol blending or the use of *ethanol credits*. The credit-trading program associated with an RFS would allow producers who use more than their pro-rata share of ethanol to earn excess ethanol credits that could be sold; producers who use less than their pro-rata share would buy ethanol credits to make up the shortfall. A credit trading system reduces the national cost of an RFS, because it concentrates ethanol use where it is least costly.

At mandate volumes of 10 and 12 bgy, domestic gasoline suppliers in PADD 2 and PADD 1 (at 10 bgy) and foreign suppliers would use more than their pro-rata share of ethanol and therefore would have excess ethanol credits that would be sold to buyers in the rest of the country. The sale and purchase of ethanol credits would lead to inter-regional monetary flows, and those inter-regional monetary flows would increase with increasing RFS mandate volume.[7] (**Figure 6**)

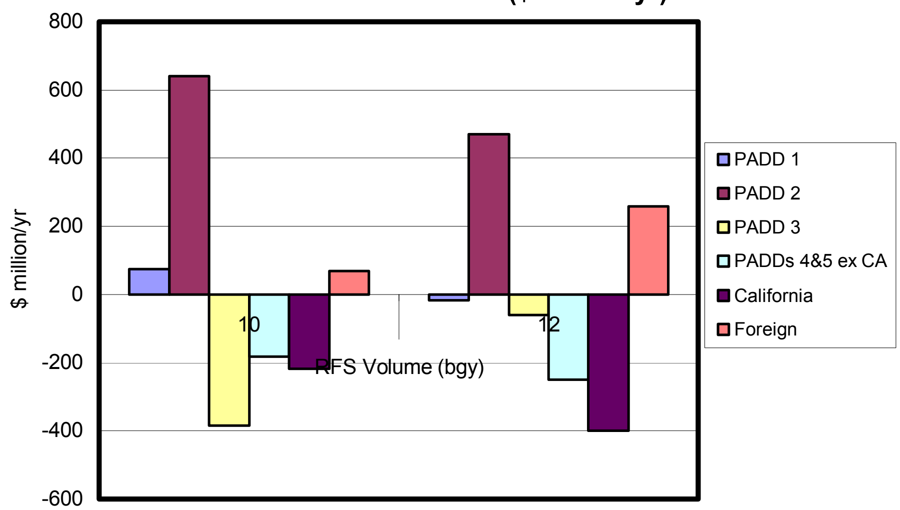
Gasoline suppliers in PADD 2 could realize net revenues from trading in the range of about **$640 million per year** at 10 bgy and **$470 million/year** at 12 bgy. Foreign suppliers could realize net revenues from trading in the range of **$70 million per year** at 10 bgy and **$260 million/year** at 12 bgy. Suppliers in PADD 1 could realize net revenues from trading in the range of **$70 million per year** at 10 bgy, but would have a small revenue outflow from trading at 12 bgy.

Suppliers in PADD 3, PADDs 4 & 5 (ex California), and California would be net credit buyers at 10 bgy and 12 bgy, and so would experience revenue outflows from trading. Suppliers in PADD 3 could experience revenue outflows of about **$380 million per year** at 10 bgy and **$60 million/year** at 12 bgy. Suppliers in California could experience revenue outflows of about **$220 million per year** at 10 bgy and **$400 million/year** at 12 bgy. Suppliers in PADDs 4 & 5

[7] To estimate the revenue flows shown in Figure 6, we assumed that (1) surplus credits would be earned in the regions producing gasoline for ethanol blending and (2) the value of ethanol credit would reflect the difference between ethanol's purchase cost and its refining value as a gasoline component.

(ex California) could experience revenue outflows of about **$180 million per year** at 10 bgy and **$250 million/year** at 12 bgy.

Figure 6: Revenue Flows from Ethanol Credit Trading under an RFS in 2012 ($ million/yr)



The pattern of estimated revenue flows at each mandate volume reflects the estimated regional distribution of ethanol use (and credit generation) at the given mandate volume. Refining economics cause these patterns to be different for different mandate volumes, accounting for the differences in regional net revenue flows at different mandate volumes.

Basis for The Findings Reported Here

The findings reported here come from a detailed technical and economic analysis, originally conducted and recently updated by MathPro Inc., of the effects of an RFS on the refining economics of U.S. gasoline supply. The analysis

- Reflects baseline ethanol use of 3.8 bgy, corresponding to DoE's projection of ethanol use in 2012, without an RFS.
- Used (1) Department of Agriculture (DoA) estimates of the net energy inputs to ethanol production (net of by-product credits); (2) Department of Energy forecasts of crude oil and natural gas prices, U.S. gasoline demand, and domestic gasoline production; and (3) Global Insight forecasts of corn prices and by-product values at different levels of ethanol use.
- Assumed continuation of (1) the federal excise tax credit for ethanol blending (currently at 51¢/gal) after its scheduled expiration in 2010, (2) the 1 psi RVP waiver for ethanol-blended conventional gasoline and (in the Midwest) low-RVP gasoline, (3) existing state tax subsidy

programs for ethanol blending (e.g., Illinois, Iowa), (4) existing state ethanol mandates (e.g., Minnesota, Arizona (winter)), and (5) existing state credits for ethanol production.

All prices are in 2003 US$. All ethanol volumes are annual averages.