# BRINGING BIOFUELS TO THE PUMP

## An Aggressive Plan for Ending America's Oil Dependence


***Principal Authors***
Nathanael Greene
Yerina Mugica


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# Executive Summary

The United States does not have to rely on oil to drive our economy and quality of life. We can replace much of our oil with biofuels—fuels made from plant materials grown by American farmers. These fuels, especially those known as cellulosic biofuels, can be cost-competitive with gasoline and diesel, and allow us to invest our energy dollars at home. They can also slash global warming emissions, improve air quality, reduce soil erosion, and expand wildlife habitat.

Shifting to biofuels would bring tremendous benefits to America's national security, economy, and environment. Oil is the Achilles' heel of our economy—a disruption of supply due to an attack on a major pipeline could send prices soaring, increasing business costs and trade deficits. In addition, our dependence funnels billions of dollars to shaky and hostile regions, rather than investing in domestic factories and farms. Defense and foreign policy experts increasingly point to our oil addiction as a "national security emergency" that must be solved by advancing petroleum alternatives, not by betting on additional oil supplies. Meanwhile, America's oil-burning cars, trucks, and buses account for 27 percent of U.S. global warming pollution, as well as soot and smog that damage human health.

Biofuels can play a central role in freeing us from this oil dependence and its hazards. If we follow an aggressive plan to develop cellulosic biofuels between now and 2015, America could produce the equivalent of nearly 7.9 million barrels of oil per day by 2050. That is equal to more than 50 percent of our current total oil use in the transportation sector and more than three times as much as we import from the Persian Gulf alone.

In combination with improved fuel efficiency in cars and smart growth planning in our towns and cities, biofuels can free America from foreign oil in a cost-effective and environmentally safe way:

- Biofuels could virtually eliminate our demand for gasoline by 2050.
- Biofuels could be cheaper than gasoline and diesel, saving us about $20 billion per year on fuel costs by 2050.
- By 2025, producing the crops to make these fuels could provide farmers with profits of more than $5 billion per year.
- Biofuels could reduce our greenhouse gas emissions by 1.7 billion tons per year—equal to more than 80 percent of transportation-related emissions in 2002.

We already use almost 4 billion gallons of ethanol a year—primarily produced from corn kernels—but this represents less than 2 percent of our current total oil use in the transportation sector. To make a significant dent in our oil dependency, we need to invest in infrastructure and markets and, most important, in new technologies—cellulosic technology that make use of a wider variety of plant material from more parts of the country and with a smaller environmental footprint. We must help the existing biofuels industry grow and evolve.

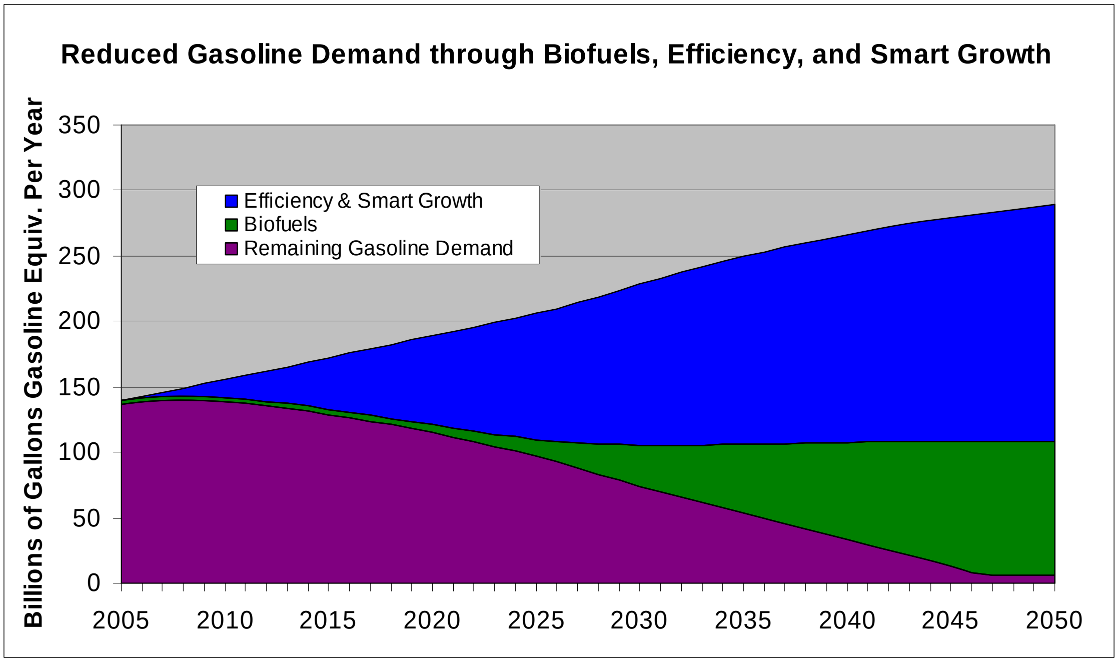


**Figure 1. How Biofuels and Efficiency Can End Gasoline Demand by 2050**

### A Three-Step Plan to Make Biofuels Affordable and Sustainable

Breaking our addiction to oil is going to require a long-term commitment to increasing efficiency, creating more livable communities that do not require as much driving, and making biofuels affordable and sustainable. To make biofuels affordable and sustainable, we recommend a package of policies with the broad goal of developing a cellulosic biofuel industry by 2015 that is cost-competitive with corn ethanol and moving rapidly toward cost-competitiveness with petroleum fuels. To achieve such an aggressive commercialization schedule, research, development, demonstration, and deployment will need to be pursued on nearly parallel tracks. Three steps are essential:

- Funding $1.1 billion in a package of research, development, and demonstration policies from 2006 to 2012 that create the innovations and advances needed for a large-scale, competitive biofuels industry.
- Investing $1 billion in deployment policies from 2006 to 2015 that drive the development of the first billion gallons of cellulosic biofuels capacity at a price approaching that of gasoline and diesel.
- Adopting policies that build infrastructure and a market for these fuels, including a responsible renewable fuels standard and flex-fuel vehicle requirements.

Taken together, these policies would create about 1 billion gallons of biofuels capacity and advance the technology to a state where it is capable of producing biofuels at costs competitive with those of gasoline and diesel.

In this paper, NRDC lays out an aggressive policy plan for making biofuels affordable and sustainable. These policy recommendations are backed by extensive, original research we conducted for our December 2004 report, *Growing Energy: How Biofuels Can Help End America's Oil Dependence.*

# Step 1: Invest in Research, Development, and Demonstration

Producing a cheap and reliable alternative to oil will be lucrative business, but the industry alone will take too long to develop the new technologies needed. The government can spur development along—and ensure that biofuels are affordable for American consumers—by investing about $1.1 billion between 2006 and 2015 in biofuels development. This kind of major research development and demonstration (RD&D) program will provide the scientific and technological foundation needed to allow the industry to deploy cellulosic biofuels rapidly.

While pre-commercial RD&D is clearly an investment in commercialization, the private sector is unlikely to invest on the scale or at the speed that we need if we are to start to wean ourselves from oil. The private sector cannot make biofuels happen without government support; the potential rewards are too long-term, and too many of the benefits are societal and hard for a single company to capture.

RD&D must focus on the three areas of greatest technological challenge:

- Overcoming the recalcitrance of cellulosic biomass: converting cellulosic biomass into a more usable source of energy through technologies such as pretreatment, biological processing, and gasification is the greatest and most important challenge.
- Coproducts: enabling biofuels plants to diversify the range of products they produce along with biofuels, such as additional fuels, animal feed protein, and chemicals, improves economics and efficiency.
- Feedstocks: getting greater crop yields and making other advances in feedstock production will reduce the cost and the environmental footprint of biofuels.

RD&D activities should also be targeted according to the different ways in which they add value. There are primarily three levels:

- Better understanding of applied fundamentals,
- Innovative technological advances, and
- Process integration, scale-up, and demonstration.

To estimate the cost of the RD&D efforts needed to prepare biofuels technology for deployment, we made a general assessment of how much each category of technology would need and then cross-checked this with an estimate created from detailed considerations of the different levels of RD&D work each category needed. A total investment of about $1.1 billion from 2006 through 2012 should produce a regular flow of advances that can be used in deployment and move the technology to a point where most of the remaining development can be done at commercially competitive facilities. After 2012, we should be able to ramp down federal funding for RD&D as the scale of challenges becomes smaller and the scale of private sector investment increases.

**Table 1. Breakdown of RD&D Support**

| | | | **Technological Category** | | |
|---|---|---|---|---|---|
| | **Necessary ratio and level of support ($ million)** | | **Recalcitrance of biomass** | **Coproducts** | **Feedstock** |
| | | | 45% | 30% | 25% |
| **Value-Added Category** | **Applied fundamentals** | 15% | $74 | $50 | $41 |
| | **Innovation** | 35% | $173 | $116 | $96 |
| | **Demonstration** | 50% | $248 | $165 | $138 |

The RD&D programs can be implemented through the Biomass R&D Development Act of 2000, which was first funded in the Farm Bill of 2002. This act established a system for open and competitive solicitations and awards made regularly based on expert peer review of proposals. Currently, biofuels RD&D grants are funded at $75 million total over six years, but this program is currently set to expire in 2007 and must be reauthorized in the 2007 Farm Bill.

Given the sky-high price of oil, the increasing clear national security costs imposed by our addiction to oil, and the mounting evidence that biofuels could make a major contribution to reducing our oil dependence, it's time to make energy production—and especially fuel production—from biomass a priority in our federal R&D funding. Compared to the ever increasing national security and environmental costs of our oil addiction, increasing our R&D funding for biofuels to $1.1 billion is an extremely reasonable investment.

Amid low overall funding levels, shifting priorities, and competing objectives and interests, governmental programs have not had the means to meaningfully address the range of activities that the expert technical community agrees are essential. Thus, in addition to increasing funding we must also allocate funds over multiple R&D levels and key technical areas. This is essential to foster a balanced approach that will maximize the rate of progress toward production of fuels and complementary co-products from biomass.

We recommend funding allocations along two tracks. Funding should be allocated to different levels of R&D based on value-added categories such that:

- Innovation receives 35 percent,
- Applied fundamentals receives 15 percent,
- Demonstration receives 50 percent.

Within these levels of R&D, funding should also be allocated to different areas of technology, such that:

- Enabling the conversion of the cellulose portion of biomass receives 45 percent,
- Developing products, along with biofuels such as power, protein, fuels, and chemicals, receives 30 percent,
- Improving the yields and sustainability of feedstocks receives the remaining 25 percent.

**WHY RESEARCH AND DEVELOPMENT AND DEPLOYMENT SHOULD HAPPEN AT THE SAME TIME**

We recommend starting deployment incentives at the same time as research, development, and demonstration policies. Placing them on simultaneous tracks ensures a rapid evolution of the technology. While innovations are needed to bring about cost-effective and sustainable cellulosic biofuels, technologies exist today that can function on a commercial scale and that will provide a wealth of information about the integrated operations of technologies.

For example, the development of biomass Fischer Tropsch production might benefit from piggybacking a biomass gasification system onto a coal-to-Fischer Tropsch facility, such as the pilot-scale project (5,000 barrels per day capacity) proposed and supported with Department of Energy funding for Gilberton, Pennsylvania.

Such facilities can serve as the launch pads for the technologies developed by the RD&D policy both in a literal sense—in that these facilities can be expanded, allowing for the rapid adoption of innovations—and through the learning-by-doing that these facilities will allow.

In many ways, the ratio of support between the technological aspects of RD&D and value-added levels of RD&D are as important as the amounts of funding. Under the Biomass R&D Act, the Department of Energy and the USDA share equally the responsibility of making funding decisions. Going forward, it may make more sense to divide administration of the RD&D budget among the categories rather than simply splitting it down the middle. Either way, the agencies should be required to meet these funding targets overall and should strive to meet them on an annual basis, the quality of the proposals permitting. Adjustments to the overall targets may be necessary, but they should be undertaken only after careful analysis and public input.

We also recommend incorporating other key measures into a reauthorized Biomass R&D Development Act, including the following:

- Open solicitations should use a consistent approach year to year.
- Objectives for the solicitations should be clearly stated, with no areas of special interest.
- Results of R&D projects supported by these funds should be made public to enable a competitive industry to develop.
- Demonstration should require a 20 percent spending match.
- Innovation and applied fundamental R&D should not require a spending match.
- Demonstration projects should be pursued in a range of geographic areas using a range of feedstocks.
- Where appropriate, demonstrations should take advantage of existing biofuels infrastructure.
- A range of lead institutions should be included.
- At least half of the reviewers for each area and type of R&D should be external experts drawn from outside of the USDA and the Department of Energy.

### Expected Impacts from Investing in RD&D

Funding $1.1 billion in research, development, and demonstration should cut the cost of ethanol production roughly in half. Of course when there are still important breakthroughs still to come, it is impossible to know exactly what the impacts of advances will be. However, by comparing the cost of current technology with forecasts of the cost and performance of advanced technologies based on input from the leading experts on each stage of the production process, we can provide insight into what the payoff from RD&D is likely to be.

Research, development, and demonstration should increase the amount of ethanol produced from each ton of dry biomass from current levels of about 84 gallons to about 105 gallons. At the same time, the amount of excess electricity produced should nearly triple. These changes, along with major reductions in the cost of raw material handling and processing capital and operations, should reduce the cost of a gallon of ethanol from about $1.26 currently to about $0.63 from advanced technologies.[1]

**Table 2. Potential Cost Savings from RD&D**

| | **MESP** | | |
|---|---|---|---|
| | **Current Technology** | **Mature Technology** | **Change** |
| **Raw Materials** | **($/gallon)** | **($/gallon)** | |
| Feedstock | 0.4852 | 0.3798 | -22% |
| Other | 0.1607 | 0.0475 | -70% |
| **Processing (Capital + Operating)** | | | |
| Feed Handling | 0.0315 | 0.0156 | -50% |
| Pretreatment | 0.1124 | 0.039 | -65% |
| Biological conversion | 0.148 | 0.0168 | -89% |
| Distillation and Solids Recovery | 0.0962 | 0.0596 | -38% |
| Wastewater Treatment | 0.0387 | 0.036 | -7% |
| Storage | 0.0062 | 0.0042 | -32% |
| Residue Processing | 0.1724 | 0.1316 | -24% |
| Utilities | 0.0209 | 0.0141 | -33% |
| Waste Disposal | 0.0373 | 0.007 | -81% |
| **Electricity Credit** | -0.0462 | -0.1203 | 160% |
| **TOTAL** | 1.2633 | 0.6309 | -50% |

Advances in gasification technologies and in producing multiple products could further reduce the cost. The most cost-competitive configuration we have identified would produce ethanol at about $0.49 per gallon of ethanol. These prices are very competitive with gasoline.

**Table 3. Cellulosic Ethanol Has the Potential to Be Cost-Competitive with Gasoline**

| **Wholesale Price per Gallon of Gasoline Equivalent** | | **High** | **Average** | **Low** |
|---|---|---|---|---|
| **Advanced Cellulosic Ethanol (depending on technology and scale) by about 2015** | | $0.91 | $0.77 | $0.59 |
| **Gasoline** | 2000 – 2004 | $1.50 | $0.91 | $0.44 |
| | 2025 – EIA Forecast | $1.03 | $0.79 | $0.48 |

# STEP 2: INVEST IN DEPLOYMENT

With oil prices skyrocketing and greenhouse gas emissions rising, we need to shift to biofuels now, not in the distant future. To make sure that at least 1 billion gallons of cellulosic biofuels are produced by 2015, the government should offer $1 billion in incentives to production facilities.

We recommend three primary goals for deployment policies. First, they should encourage construction and operation of enough capacity so that, in combination with aggressive RD&D, plants built after 2015 are technically capable of producing biofuels at costs competitive with corn ethanol and ideally with gasoline and diesel. Second, they need to minimize the risk of failures that will give the industry a black eye and waste public dollars. To do this, they should interfere as little as possible with private sector due diligence. Finally, it is crucial that the policies ensure that the industry is self-sufficient when the policies expire. Producing biofuels that are at least cost-competitive with corn ethanol will ensure that the industry can survive in the marketplace without additional government support.

Achieving these goals requires overcoming a host of challenges. Each project will face financing challenges to a different degree, making it hard to design a one-size-fits-all incentive mechanism. Furthermore, as the technology develops, the challenges will shift, allowing production incentives to play an increasingly important role. Unfortunately, subsidies tend to lead to addiction on the part of industry; thus, subsidies are hard to eliminate and the industry cannot stand on its own. The industry will plan for independency and public dollars will be better spent if a phaseout of support is clearly built into policies from the beginning.

Generally speaking, the government is poorly equipped to determine the most promising projects and to determine how the needs of the industry change over time. Furthermore, government incentives that are subject to annual appropriations are high risk and greatly discounted by financiers. With developed technologies, performance-based incentives have proven very effective as deployment policies. However, because performance-based incentives pay only for successful operation, for technologies never used before on commercial scale, they can reduce but not eliminate the finance barrier. There is a lot of history of using loan guarantees for innovative technologies, which can effectively make financing available, but as traditionally applied, these also reduce the incentive to the financial community to perform a rigorous due diligence review on projects. Furthermore, loan guarantees are often viewed as a sign of a technology that does not work rather than a badge of approval. The result: failed projects that have cost taxpayers millions and set developing industries back years.

### Making Deployment Incentives Most Effective

The key components of our deployment policy recommendations are to:

- Use a mix of investment and production incentives. Investment incentives are more risky but are essential for first-of-kind technology projects.

- Use a menu approach that lets developers choose their mix of funding options under an overall cap—each project will be different and face different financial challenges. This approach allows developers to use the incentives in the most effective way while still ensuring that the project is not overly reliant on public dollars.
- Reduce the value of incentives over time. This is essential to ensure that the industry ends up competitive.
- Cap the total cost to the government for deployment incentives at $1 billion over 10 years. This is important to demonstrate that in comparison to the economic, security, and environmental costs of oil, this is not an expensive program.

We recommend making three types of deployment incentives available: partial and limited-term loan guarantees, tax-exempt financing, and performance incentives. Developers should be allowed to take any combination of these incentives they choose as long as the total value of the incentives remains below the values presented in the following table.

**Table 4. Overall Caps on Deployment Incentives**

| Projects on line by: | Total Value of Incentives over the Life of a Project: The lesser of: | | |
|---|---|---|---|
| | **Per million gallons capacity** | **Percent of total capital cost** | **Total dollar amount** |
| Year 4 | $5.6 million | 88% | $80 million |
| Year 6 | $4.5 million | 50% | $75 million |
| Year 10 | $1.5 million | 15% | $25 million |

### *Partial and Limited-Term Loan Guarantees*

Loan guarantees can be an extremely effective way to address the technology risk associated with first-of-a-kind plants.[2] However, if used without restrictions they can put taxpayer dollars at risk and virtually eliminate the incentive for debt lenders to undertake due diligence. To minimize the risks associated with loan guarantees, we recommend only guaranteeing part of a project's debt and limiting the term of the guarantee.

Specifically, the government should offer up to $2 billion in loan guarantees, but no project should be allowed to receive a guarantee of more than 80 percent of its total project debt, or $100 million, whichever is smaller. Both the percent and total value cap should decline over time. The loan guarantee should be used to either make fixes or pay senior debt, and payments should be tied to proportionately equal forfeiture of the developer's fees. Finally, the guarantees should be limited in duration to no more than 20 years. The table below shows the maximum guarantee that any given project should be allowed to receive.

**Table 5. Caps on Loan Guarantee**

| Projects on line by: | Maximum Loan Guarantee: The lesser of: | | | |
|---|---|---|---|---|
| | **Per million gallons of capacity** | **Percent of total debt** | **Per plant** | **Estimated Average Loan Guarantee Subsidy Cost per plant** |
| Year 4 | $5.6 million | 80% | $100 million | $10 million |
| Year 6 | $5.25 million | 75% | $90 million | $ 9 million |
| Year 10 | $4.9 million | 70% | $85 million | $ 8.5 million |

The value of the loan guarantee toward a project's overall incentive limits should be calculated in the same way that the Department of Treasury calculates the cost of the loan guarantee to the government.[3] To the extend that any of the loan guarantees expire during the 10 years of this program, the funds used to securitize the guarantee should be used again to offer additional guarantees.

### *Tax Exempt Financing*

Tax exempt financing reduces the cost of debt for a project, but the option is generally limited to government bonds. However, a limited number of "private activity bonds" are authorized each year to nongovernment projects that provide a public benefit. We recommend establishing a 10-year program of private activity bonds for cellulosic biofuels projects. The value of these bonds toward the project's overall incentive limits and toward the overall cost of this program should be calculated as the cash equivalent of the reduction in interest rate received by the project as a result of using tax-exempt financing.

Typically, projects taking advantage of tax-exempt private activity bonds are not allowed to also take advantage of federal loan guarantees or to use accelerated depreciation. However, because this deployment package is explicitly intended to allow developers to mix and match incentives, projects taking advantage of these bonds should be exempted from this restriction. Projects using tax-exempt financing should be allowed to use accelerated depreciation, an advantage generally given to developing technologies, as well as federal loan guarantees.

### *Performance Incentives*

In the early years of an overall incentive program, we anticipate that the financial community will greatly discount the value of performance incentives because of the perceived technology risk. We recommend that for the first six years of this program, performance incentives should be fixed and available to any project that comes on line during these years. This will maximize the value of these incentives and encourage developers to take as much of their incentives as performance incentives.

After the sixth year, projects should be required to compete with each other for performance payments, and those projects requiring the least incentives should win the competition. This process is known as a reverse auction, and it allows the auctioneer—the federal government in this case—to get the most gallons of cellulosic biofuels for the least amount of dollars.

For both phases of the performance incentives, payments should be made on a fixed dollar per gallon basis over the first six years of the project's operation. The value of the incentives should be capped on a dollar-per-gallon basis, dollar-per-million gallons of capacity, and as a fraction of the projects total capacity cost. Developers should have the option of taking the incentives as either a tax credit or a cash payment. Either way, the value of the performance incentives toward a project's overall incentive cap should be calculated as the simple sum of all the payments.

The table below shows how the production incentives should be capped over the different stages of this program.

**Table 6. Caps on Performance Incentives**

| Projects on Line by: | Production Incentive per Gallon | Total Value of Production Incentives: The Lesser of: | |
|---|---|---|---|
| | | **Per million gallons capacity** | **Percent of total capital cost** |
| Year 4 | $0.90 | $5.4 million | 84% |
| Year 6 | $0.33 | $3 million | 30% |
| Year 10 | Reverse Auction—maximum limit of $0.13 | $1 million | 10% |

### *Impacts of Investing in Deployment*

An analysis of how this package of incentives would affect "typical" early cellulosic ethanol plants illustrates both the effectiveness of the incentives and why a package approach is preferable. For example, an average first-of-kind small cellulosic ethanol plant without any support (and therefore we assume requiring 100 percent equity) would probably produce ethanol at a cost of nearly $6.38 per gallon.[4] Alone, any of the incentives provided in this package would lower this cost to between $4.19 and $2.59. Taken in combination, however, the performance incentives with either the loan guarantee or the tax-exempt bond lower the cost to about $1.35. As the technologies advance over the 10-year period of the program, until year 10, the package should lower costs for new plants to about $0.93 per gallon—roughly equivalent to the current wholesale price of both gasoline and ethanol from new corn-based facilities.

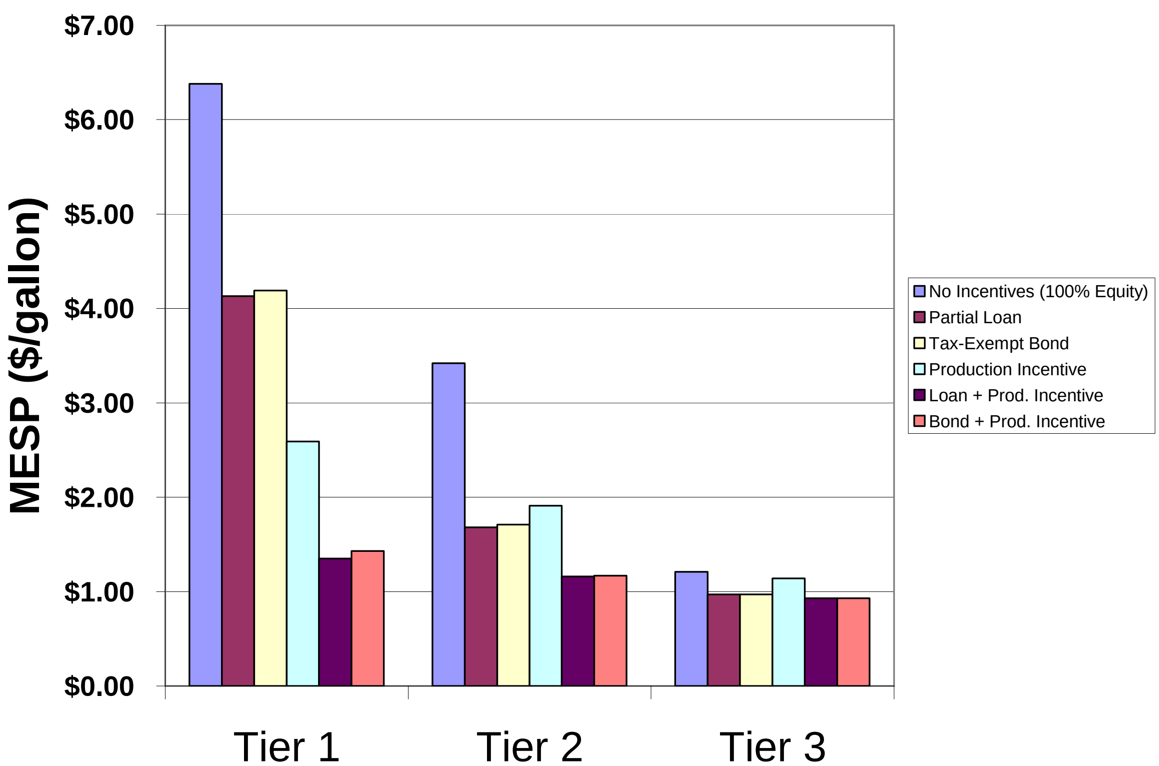


**Figure 2. Minimum ethanol selling price (MESP) for various cellulosic ethanol deployment incentives using 50/50 D/E**

In other words, the incentives are very effective at lowering the costs, and while the structure encourages plants to use more than one incentive, for an average plant the different incentives and combinations of incentives generally have similar impacts.

However, changes in the financial structure of a first-of-kind plant result in different combinations, reducing costs much more than others. For example, if early plants have limited access to private debt, then the loan guarantee has much more value than the tax exempt bonds. The fact of the matter is that it is impossible to design a single incentive that will work for all different potential project configurations, especially as those configurations change over time. The package approach is flexible and effective.

# STEP 3: ADOPT POLICIES TO BUILD INFRASTRUCTURE AND A MARKET

Research, development, demonstration, and deployment of cellulosic biofuels technology are the foundation of using biofuels to reduce our oil dependence. They will drive crucial innovations in technology and reductions in production costs. However, these advances alone will take a long time to penetrate the transportation fuel market, and the inertia of the existing petroleum-based transportation sector will delay any transition. For these fuels to make a big impact on our oil dependency soon, we must also simultaneously develop the infrastructure and market for these fuels. A renewable fuels standard and policies to require a growing portion of our vehicles to be flexible fuel capable (*i.e.*, capable of running on either gasoline or ethanol) over time are two important policies that will help drive down our dependence on oil and enable a shift from gasoline and diesel to renewable alternatives.

### A Responsible Renewable Fuels Standard

NRDC supports a carefully crafted 8 billion gallon renewable fuel standard (RFS) that includes air quality protections, and could be implemented this year and would achieve the following important goals:

- More than double our use of renewable fuels and reduce our dependence on petroleum by 0.34 million barrels per day.
- Reduce greenhouse gas emissions from the transportation sector by 35 million tons per year.
- Improve air quality in ozone areas that do not meet pollution standards, also known as non-attainment areas.
- Minimize the ozone pollution caused by using low-percentage ethanol blends in ozone attainment areas.
- Make the first firm commitment to commercializing cellulosic biofuels.

All of the elements needed to create a sustainable transition to renewable fuels exist. We must carefully combine these elements to ensure maximum air quality, public health, and economic benefits are realized. Increasing the role of cellulosic biofuels, phasing out the use of methyl tertiary-butyl ether (MTBE) in gasoline, and eliminating the federal requirement to add oxygenates to reformulated gasoline are crucial steps to take as we expand the role of sustainable biofuels in our transportation system.

There are 11 key features that a RFS must have. These features can be grouped into three categories: protecting air quality, encouraging cellulosic biofuels, and avoiding unintended consequences.

**FOUR COMMON QUESTIONS ABOUT A RENEWABLE FUEL STANDARD (RFS)**

**Q: An RFS will support existing biofuels technologies; do these really save energy?**
**A:** Yes. A carefully crafted 8 billion gallon RFS with a 1 billion gallon cellulosic biofuels requirement might well require up to 7 billion gallons of fuel to be produced using existing corn-to-ethanol technology. The best science currently supports the conclusion that ethanol from corn kernels contains more high-quality energy than it takes to grow the corn and process the fuel. In addition, we should maintain and expand the existing biofuels industry because it saves oil and provides the foundation for a much larger biofuels industry based on cellulosic technologies.

**Q: Does (starch-based) corn ethanol save oil?**
**A:** Yes. While producing ethanol from the starch in corn uses more fossil fuel than ethanol from cellulosic biomass will, ethanol from both sources actually uses very little petroleum. Ethanol from corn kernels or from cellulose uses 93 percent less petroleum than an equivalent amount of gasoline. The reason the biofuels industry needs to evolve away from just corn kernels to cellulose is so that it can grow much larger and still remain sustainable.

**Q: If cellulosic biofuels are the future, shouldn't we limit an RFS to those fuels?**
**A:** No. Existing biofuels technologies save oil, reduce greenhouse gases, build infrastructure, and develop markets. These technologies are the foundation from which our transition away from petroleum will be launched.

**Q: Will an RFS increase the price of gasoline?**
**A:** Unknown. Existing government studies find that an RFS will increase the price of gasoline by a few cents, but all of these studies are based on outdated oil and ethanol prices. Currently, wholesale ethanol is virtually the same price as gasoline and even cheaper than gasoline in some parts of the country. If oil remains expensive and ethanol continues to get cheaper due to increased supply and new technologies, an RFS will actually lower the price of gasoline.

**Q: Will an RFS make air quality worse?**
**A:** Not if the right provisions to protect air quality are included in an RFS. Even the U.S. EPA now recognizes that increased use of low blends of ethanol with gasoline (*e.g.* 10 percent ethanol and 90 percent gasoline) increase urban smog. Moving forward with an RFS without provisions to protect air quality would result in an unacceptable and unnecessary trade-off between public health, rural development, and oil security.

**Table 7. Key Features of a Successful Renewable Fuel Standard**

| Category | | Critical Feature | Description |
|---|---|---|---|
| Protect Air Quality | 1. | Make the standard least-cost and flexible. | Include a credit trading mechanism. |
| | 2. | Provide fuel flexibility. | Eliminate oxygenate mandate for reformulated gasoline. |
| | 3. | Prevent additional pollution in already polluted areas. | Do not require non-attainment areas to blend ethanol during the summer. |
| | 4. | Prevent new sources of air pollution. | Eliminate allowance for ethanol to emit more evaporative emissions than conventional gasoline. |
| | 5. | Give states more tools. | Allow reformulated gasoline opt-in for eight-hour non-attainment areas. |
| | 6. | Update baseline year for backsliding standard. | Set 2002–2003 as the baseline year for anti-backsliding to prevent increase in air toxics. |
| | 7. | Update the EPA Emissions Model (*i.e.* "Complex Model") to prevent criteria air pollutant backsliding. | Before an RFS is in place, it is critical that the EPA complex model be updated to ensure air quality is maintained. |
| Promote Production of Sustainable Biofuels | 8. | Establish a cellulosic ethanol blending requirement. | Require the use of a specific volume of cellulosic ethanol in order to help drive the evolution of starch ethanol to cellulosic ethanol. |
| | 9. | Establish a renewability index standard to ensure continuous improvement. | Establish a performance-based index to drive innovation and reward more efficient and environmentally beneficial fuel production. |
| | 10. | Appropriately define biomass. | Limit biomass definition to include only truly renewable resources and exclude resources whose use would result in negative environmental impacts (such as municipal solid waste). |
| Avoiding Unintended Consequences | 11. | Protect water quality and avoid unintended negative consequences. | Do not include any liability waiver provisions. |

### Advancing Renewable Fuels While Protecting Air Quality

Cellulosic biofuels have the potential to improve overall air quality, but we must be careful in designing and implementing an RFS to capture this potential and avoid unintended consequences. A responsible RFS must contain safeguards to ensure that air quality standards are maintained during the transition to renewable fuels. If done poorly, there is the potential to exacerbate air and water pollution problems and not contribute meaningfully to a long-term transition away from petroleum.

The greatest near-term challenge to increasing our use of renewable fuels is protecting air quality, particularly ground level ozone pollution. Right now, ethanol is the most widely used biofuel. It has two major uses. The first is as an oxygenate intended to help gasoline burn more cleanly and fully. For this purpose, it is generally blended with gasoline at between 5 and 7 percent by volume. The Clean Air Act amendments of 1990 mandate that reformulated gasoline is blended with oxygenates, and the only two approved oxygenates are MTBE and ethanol. MTBE has been found to contaminate groundwater supplies and many states have banned its use. NRDC strongly supports these bans but notes that they create a de facto mandate to use ethanol in reformulated gasoline. Since the oxygenate requirement came into effect, petroleum refiners have also found alternative ways to reformulate gasoline that provide all of the same air quality benefits without using oxygenates. NRDC supports the elimination of the oxygenate requirement.

**LOW-PERCENTAGE ETHANOL BLENDS AND OZONE POLLUTION**

Unfortunately, low-percentage blends of ethanol into gasoline present a challenge to air quality. While the ethanol industry disputes some of the science, the air impact models of both the U.S. Environmental Protection Agency and the California Air Resource Board predict that using E10 generally increases ground level ozone pollution. A draft report released in February by the California Air Resource Board found, based on new studies of the emissions from the use of low blends, substantially higher impacts than previously thought. The pathways for these impacts are multifold and complicated, but the three primary sources are related to emissions of nitrogen oxide (NOx), carbon monoxide (CO), and volatile organic compound (VOC), all of which are precursors to ground level ozone pollution.

The increased ozone pollution associated with low blends is a seasonal and transitory problem. It is seasonal because ozone is formed when NOx, VOC, and CO are “cooked” by sunlight. It is transitory because new cars designed to meet regulations that went into effect last year in California and will be in effect nationally in 2007 must achieve lower overall emissions of these precursors. Unfortunately, these new vehicles will not entirely displace the older, more polluting vehicles until between 2020 and 2025, depending on the part of the country.

Fortunately, with the right air quality protection measures, the United States can use 8 billion gallons of ethanol without having to use it in either reformulated gasoline or in regions of the country that suffer from ozone pollution during the summer. In other words, there is no need to trade off public health, rural development, and oil security.

The second use of ethanol is as an alternative to gasoline. One of the strong points of ethanol is that when blended in a mixture of up to 10 percent with gasoline (known as E10), it can be used in all gasoline powered motor vehicles on the road today. This offers an appealing transition pathway away from oil—we can use E10 until we have enough vehicles on the road that can use higher blends.

Adding low-percentage blends of ethanol to gasoline increases pollution. In the absence of air quality safeguards, expanded use of ethanol will increase smog, which makes the air unhealthy to breathe for millions of Americans. When ethanol is mixed with gasoline in a low percentage blend, as in E10 (10 percent ethanol, 90 percent gasoline), it increases significantly evaporative emissions of smog-forming hydrocarbons (also known as volatile organic compounds). New data demonstrate that this problem is worse than previously anticipated because ethanol increases the permeation of gasoline through hoses and other soft components of vehicle fuel systems. While the use of ethanol also reduces some combustion-related tailpipe emissions, the EPA has determined that the net effect is an increase in smog-forming pollution given its current fuel regulations. That said, transitioning to high-percentage blends of ethanol, as in E85 (85 percent ethanol, 15 percent gasoline) has the potential to *improve* air quality. The challenge is to responsibly manage the transition.

***Protect Air Quality***

In order to be able to use 8 billion gallons of renewable fuels in the seasons, places, and ways that will protect air quality, the following seven measures are essential parts of a renewable fuel standard:

1. **Make the standard least-cost and flexible by including a credit trading mechanism.** A credit trading system will also help refiners in states and localities with fuel performance standards that either limit or exclude ethanol to comply with an RFS. This is critical for protecting air quality. In addition, we can minimize the cost of the RFS by allowing petroleum refiners to comply with an RFS through credits that are bought and sold.
2. **Provide fuel flexibility by eliminating the obsolete oxygenate mandate for reformulated gasoline.** Scientists agree that the 1990 Clean Air Act requirement to add an oxygenate (the so-called oxygenate mandate) into reformulated gasoline is no longer necessary due to advances in reformulation and in air pollution control technology on motor vehicles.[5] The oxygenate mandate currently requires the use of ethanol in areas that can least afford the air quality challenges posed by low blends. Eliminating the oxygenate mandate and at the same time establishing a well crafted RFS will ensure that the market for renewable fuels continues to grow while allowing for ethanol to be used outside of regions with ozone pollution problems.
3. **Prevent additional pollution in already polluted areas by ensuring that protecting air quality has priority over requirement to minimize seasonal variations.** Because blending ethanol into fuel during ozone season would result in higher volatile organic compound emissions, states with non-attainment areas may need to reduce their use of ethanol-blended fuel during the summer ozone/smog season. This raises concerns for the ethanol industry over storage. The industry has lobbied for a requirement that a minimum amount be used nationally in each season. We recommend prioritizing air quality over a seasonal use requirement and providing support for seasonal storage, if necessary.
4. **Prevent new sources of air pollution by eliminating allowance for gasoline blended with ethanol to emit more evaporative emissions than conventional gasoline.** Currently, the Clean Air Act includes the so-called 1 pound waiver that allows ethanol and conventional gasoline blends to release higher evaporative emissions by having a Reid Vapor Pressure 1 pound higher than pure conventional gasoline. Higher evaporative emissions mean more ozone, and the negative health effects of ozone have been found at very low levels. Simply because an area meets ozone standards does not mean that there will not be public health costs from increased ozone pollution. The 1 pound waiver should be eliminated, especially in non-attainment areas for the eight-hour ozone National Ambient Air Quality Standards (NAAQS). This will help to reduce toxic and evaporative emissions across the country.
5. **Give states more tools by allowing them to use reformulated gasoline in more areas.** In 2004, the EPA established eight-hour ozone NAAQS that are slated to go into effect in 2007. While there is overlap between areas that will not be in attainment with the new eight-hour standards and those that already use reformulated gasoline, the eight-hour standards will affect a broader area. Unfortunately, these new areas are currently not allowed to use reformulated gasoline to help reduce ozone pollution. Any state should be allowed to include these newly identified air quality problem areas in the reformulated gasoline program. This is one of the best ways states can protect against increases in air pollution caused by increased use of low blends of ethanol; the key causes of increased air pollution must be more strictly controlled in reformulated gasoline. Allowing states to opt-in will increase the amount of reformulated gasoline used and therefore reduce the amount of gasoline into which ethanol can be blended. A 2002 EPA study estimated that if all of the eight-hour non-attainment areas used reformulated gasoline, it would increase the demand for reformulated gasoline by 12.6 percent.
6. **Update the baseline year for the backsliding standard to prevent an increase in air toxics.** There are concerns that using ethanol may increase toxic air emissions, in addition to ozone. The potential for this is far from certain. Gasoline, for example, has benzene and butadiene, some of which is emitted as air pollution. Biofuels will limit those emissions, because biofuels don't even contain those toxins. In contrast, the combustion of ethanol results in the formation of aldehydes. To ensure that increasing our use of renewable

fuels does not lead to an increase in toxic emissions, current proposals for an RFS include a requirement that there be no backsliding on air toxics—in other words, gains achieved must be maintained. Unfortunately, these provisions generally use a 1999 baseline. Significant air toxics reductions have occurred over the past decade. A baseline year of 2002 or 2003 should be used to evaluate whether backsliding on air toxics emissions has occurred, rather than 1999.

7. **Update the EPA emissions model (i.e. "complex model") to prevent criteria air pollutant backsliding.** The EPA uses a computer model, known as the complex model, to determine whether a given formulation of reformulate gasoline will meet the requirements established in the Clean Air Act. This model should be updated by the time the RFS goes into effect in order to to incorporate the best available data on the effect of ethanol on emissions, especially the permeation of hydrocarbons through vehicles' fuel systems. Without such updates to the complex model, the requirement to avoid air quality backsliding will be ineffective.

### Promote Production of Sustainable Biofuels

American farmers and refiners are already producing billions of gallons of ethanol from corn. But to produce enough biofuel to make a significant dent in our oil dependence, the industry has to evolve from relying on starch from corn plants to using cellulosic biomass from whole plants such as switchgrass. This will allow us to make a much more efficient use of our biomass resources, generating more fuel in a more sustainable manner.

While cellulosic biofuels have the potential to be economically competitive with petroleum-based gasoline, significant investment is needed to reach its full potential. To pull this technology into the market, we propose a requirement that an initially small but growing percentage of the RFS be met through cellulosic ethanol.

While commercializing cellulosic biofuels will allow for using a much wider supply of biomass and a much greater supply of biofuels, we must carefully define the type of biomass that would be promoted under an RFS or the demand for biomass may threaten our wild places and environment. In the long run, the RFS should shift to encouraging the renewable fuels with the greatest performance in terms of oil savings and reduced greenhouse gas emissions. But, these fuels should reach those goals and environmental goals as well. To aggressively and safely promote sustainable biofuels, an RFS must include the following three measures:

8. **Establish a cellulosic ethanol blending requirement.** Cellulosic ethanol has greater long-term potential to reduce U.S. oil dependency, reduce greenhouse gas emissions, and be economically self-sufficient than an industry based almost exclusively on starch-based corn ethanol. To drive development of commercial scale facilities for cellulosic ethanol, a specific volume of cellulosic ethanol should be required, as part of the overall RFS. The cellulosic ethanol volume should be initially 1 percent of the total mandate, rising to at least 4 percent in 2012 and 12.5 percent, or 1 billion gallons, by 2015. This requirement will provide essential market security needed for the financial community to invest in cellulosic technology.
9. **Establish a renewability index standard to ensure continuous improvement.** A responsible RFS will provide incentives for innovation and for improvements in the production processes of fuels. These incentives should transition to a performance basis that requires continuous improvements in the overall mix of renewable fuels used. To achieve this, a performance-based index should be established that values the oil savings and greenhouse gas emissions reduction benefits of the renewable fuels supplied under the RFS. The EPA should set the index every year to ensure continuous improvements in the benefits delivered by the renewable fuels.

The index will reward more efficient and environmentally beneficial fuel production in the most flexible and accurate way possible.

10. **Define biomass appropriately so that fuels are truly "renewable."** While improvement in cellulosic biofuel technology has the potential to increase the supply of biofuels greatly, it could potentially encourage the use of biomass types that are decidedly not renewable. It is critical that an RFS not include an overly broad definition of biomass. A responsible definition of biomass must incorporate the following.
    a) Biofuels derived from forest biomass should be restricted to fuels made from trees removed from the immediate vicinity of homes, or pre-commercial thinnings where endangered forests are already protected and low-impact logging is faithfully implemented. Endangered forests, which include old growth forests, critical habitat for rare, vulnerable, or endangered species, and roadless areas, are not a "renewable" resource; once cut down, they can take centuries to replicate. There is a role, however, for the federal government to support the removal of the most flammable wood biomass from communities at risk of forest fires. In addition, where natural forests are converted to plantations or non-forest uses after 2005, fuels derived from the forest biomass and from the ensuing uses should be excluded from the RFS.
    b) The definition of biomass should limit the use of animal waste to small- and medium-sized facilities. If the economic viability of large livestock operations is enhanced by producing biofuels, then water quality may be degraded.
    c) Since incineration of municipal solid waste results in emissions of hazardous air pollutants (particularly dioxins and mercury) and competes with reuse and recycling programs, it should only be included in the definition of cellulosic biomass ethanol if: a) the recyclable or compostable portion of the waste stream can be separated from the nonreusable portion, and b) the conversion of the remaining portion into biofuels does not result in the emission of hazardous air pollutants.

### Protect Water Quality and Avoid Unintended Consequences

The story of MTBE—originally one of the two permitted oxygenates for reformulated gasoline that was later discovered to contributing significantly to the pollution of groundwater across the country—has taught us the importance of product liability. If companies that make and use chemicals such as MTBE are not held responsible for these chemicals, then the public is left to clean up the mess. Unfortunately, some would like to use the RFS as a vehicle for an inappropriate waiver of liability for MTBE, and others look to shield renewable fuels. These efforts prompt us to recommend that an RFS:

11. **Does not include any liability waiver provisions.** An MTBE liability waiver would be an irresponsible shifting of the burden from those who developed and used the chemical to those who suffer from it. We are unaware of any similar water pollution risk related to ethanol, yet neither did we anticipate the water pollution problems caused by MTBE. While renewable fuels provide many public benefits, it is essential that manufacturers and distributors are held responsible for the safety and performance of their products. Liability waiver provisions could deny affected communities appropriate redress, eliminate an important disincentive to pollute, and create a dangerous precedent for future environmental policy.

### *Requiring Flex-Fuel Vehicles*

We also need to build more cars that can use new fuels. Unfortunately, current vehicle policy to encourage flex-fuel vehicles production actually increases oil consumption. Under Corporate Average Fuel Economy (CAFE) standards, automakers garner added credits for building ethanol-capable vehicles even if those vehicles never see a drop of ethanol. This has proven a lucrative loophole for automakers, which can use the credits to boost their fleet fuel economy without actually delivering more efficient cars. The result has been lower real-world fuel economy than required by law.

The short-term policy priority is to close the flex-fuel vehicles loophole, replacing it with a system in which CAFE credits go to vehicles based on the amount of ethanol they consume. The end result will be a system that rewards oil savings from new cars and encourages the use of ethanol fuel. The long-term solution to solving the traditional chicken-and-egg challenge of alternative fuel introduction is to eventually require ethanol capability for all new vehicles. There are already millions of flex-fuel vehicles on the road today, and in many new models of light-duty vehicles the only change required is in the programming of the computer that controls the engine. In other words, there are no significant technical or cost challenges to such an approach. We recommend a phased-in production requirement for alternative fuel and flexible fuel vehicles as a percent of all new light duty vehicles with the following targets:

- 10 percent for model year 2009
- 20 percent for model year 2010
- 35 percent for model year 2011
- 50 percent for model year 2012.

# ENDNOTES

[1] These costs are based on plants with the same feedstock input rate (5,000 dry tons/day), the same operating hour (8,400 hours per year), and identical financial parameters. For more details about the technologies involved in advanced cellulosic technologies, please see *Growing Energy*.
[2] In *Growing Energy*, we initially recommended efficacy insurance as an alternative to loan guarantees, but the consensus among experts we have talked to since the report's release is that this type of insurance would be very hard to develop and the risk of litigation over the payout of the policy would greatly diminish the policy's value.
[3] Generally, this is calculated based on the probability of default and the potential amount of recovery by the government in the event of a default.
[4] We assume that initially an unsupported plant would not be able find any private sector debt. With support, an average plant is assumed to have a debt/equity ratio of 50/50 and to increase in size from 14 million gallons per year to 67 million and then to 105 million during each of the phases of this program. Yields are also assumed to improve, and the internal rate of return required by equity investors declines. When available, private debt is expected to be 9 percent, tax exempt bonds are 8 percent, and loans backed by government guarantees are 6.5 percent.
[5] EPA (1999), "Achieving Clean Air and Clean Water: The Report of the Blue Ribbon Panel on Oxygenates in Gasoline," (EPA420-R-99-021).