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PLANTS AT THE PUMP: REVIEWING BIOFUELS' IMPACTS AND POLICY RECOMMENDATIONS[1]

BRITT CHILDS STALEY AND ROB BRADLEY

EXECUTIVE SUMMARY

As biofuels become a larger part of the social, economic, and environmental strategies of countries around the world, standards and regulations are needed to ensure that biofuels do in fact reduce greenhouse gas (GHG) emissions and promote sustainable development.

In a world of rapidly rising GHG emissions and growing unease about imported oil, the appeal of renewable fuels is growing apace. Biofuels — liquids produced from plant matter that can substitute for gasoline or diesel fuel — have become a hot topic from Capitol Hill to Silicon Valley. Despite their promise, however, recent research suggests that most of today's biofuels increase GHG emissions compared to gasoline or diesel fuel. These increases in greenhouse gas emissions primarily result from land-use changes associated with growing crops for biofuels. The scale-up of biofuels to meet market demands for alternative fuels should therefore be examined further for its impacts on greenhouse gas emissions.

Greenhouse gas emissions concerns, coupled with rising global food prices, have called into question biofuels policies, and some of the "silver bullet" sheen has begun to wear off. Policy makers should understand that the term "biofuels" covers a range of products with varying potentials to achieve energy, climate, transportation, or agricultural policy aims. A key policy question, then, is how to ensure that biofuels do not cause greater harm than good. Policy makers should:

- Use technology-neutral policies, as opposed to technology-specific policies such as biofuel subsidies, to drive fuel choices in relation to desired policy goals (e.g., greenhouse gas reductions, energy security, and other social and environmental priorities).
- Design methodologies for calculating the sustainability benefits of fuel options and incorporate these calculations into energy, climate, agricultural, land use, and trade policy.
- Establish certification programs to avoid "exporting" negative impacts of biofuels production to other producing countries where regulation is not yet in place.
- Recognize that biofuels alone will not provide the low-carbon transportation solutions needed to address climate change. Policy support for other mobility options, such as increased efficiency in the immediate term, or electricity for vehicle propulsion accompanied by an aggressive rise in zero-carbon power generation, should be explored. Addressing emissions from transport will ultimately require rethinking how cities are designed and must include an aggressive push toward improved public transportation.

10 G Street, NE Washington, DC 20002
Tel: 202-729-7600 Fax: 202-729-7610
www.wri.org

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Introduction

In a world of rapidly rising greenhouse gas (GHG) emissions and growing unease about imported oil, the appeal of renewable fuels is growing apace. Biofuels — liquids produced from plant matter that can substitute for gasoline or diesel fuel — have become a hot topic from Capitol Hill to Silicon Valley. They have attracted significant policy support and private investment. Increasingly, however, policy makers and investors are under pressure to ensure that their support for biofuels does not generate negative consequences. This note explores issues that the U.S. Congress should take into account when considering further support for biofuels.

For those concerned about climate change, biofuels at first looked like a win-win. Today, transport fuels account for about 30 percent of the U.S.'s carbon dioxide (CO_2) emissions, the leading greenhouse gas contributing to global warming.[2] With increases in population and income, fuel consumption is expanding worldwide; with high energy prices, alternatives to fossil fuel are increasingly attractive. However, transport fuel use is also closely linked with such issues as mobility, lifestyle choices, land-use patterns, and international trade. To consider only fuels in designing sustainable transport solutions is therefore inadequate.

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In fact, biofuels are not a complete, nor even the primary, solution to our mobility needs. Biofuels have the potential to play some role in fulfilling future energy demand, but relying on them for significant reductions in GHG emissions may not be feasible. Given the land-use changes that can result from expanded biofuels production, negative impacts such as significant destruction of forests and rising food prices may undermine the potential benefits that biofuels could bring. Policy makers should look beyond biofuels to examine other policy options such as taxation, mandated efficiencies, and improved public transport to restrain transport fuel demand.

All Biofuels Are Not Equal

The term "biofuels" covers a range of products, including some that have potential social and environmental benefits, but others that can cause significant environmental harm.

Policy makers often see biofuels as a potential solution to energy security concerns, supplementing oil supply with domestically produced biofuel. However, biofuels production requires fossil fuel input, and the energy and GHG benefits of biofuels depend largely on the kind of crop and the land used to grow it, as well as the production method and how it is fueled.[3] A full explanation of the climate impacts of different kinds of biofuels is extremely complex. However, recent research suggests that, after accounting for the carbon emissions that result from all of the land-use changes from expanded biofuels production, most of today's biofuels actually lead to an increase in GHG emissions compared to gasoline or diesel fuel.[4]

Not all biofuels are low-carbon fuels.

Global biofuels production today is dominated by ethanol from sugarcane in Brazil, ethanol from grains in the U.S., and biodiesel from oil seeds in the European Union (E.U.).[5] The technologies for producing these fuels have been in use for many decades, with mixed results in terms of fuel savings and GHG reductions. Brazilian sugarcane is relatively easy to turn into ethanol, and the energy required can largely be derived from other parts of the plant itself. Conversely, producing ethanol from grain and corn, as is done in the U.S., is an energy-intensive business, typically yielding a fuel containing only 1.3 to 1.5 energy units for each energy unit used in production.[6]

The energy and carbon benefits of biodiesel vary widely depending on the feedstocks used. Palm oil-based biodiesel, for instance, outperforms Brazilian sugarcane ethanol on an energy input-to-output basis, but palm oil biodiesel does not perform as well in terms of life-cycle GHG emissions and may actually lead to an increase in GHG emissions if forests or peatlands are burned to clear land for palm oil plantations.

While tropical biofuel production — as with Brazilian sugarcane or Southeast Asian palm oil — is energy efficient in terms of the inputs required to produce the fuel, significant emissions directly result from the land-use changes that accompany scale-up of biofuels production. In the case of palm oil, both deforestation to make way for plantations and the drying of peatlands (which release vast quantities of carbon dioxide when burned) should be taken into account and can easily cancel out any emission reductions achieved by reduced use of fossil fuels.[7] In the case of sugarcane, the emissions resulting from land use changes are less direct, as the sugarcane itself is not generally grown on newly deforested land. However, expanding sugarcane production creates competition with other land uses such as cattle ranching or soy farming, and puts further pressure on land availability.[8] This pressure can result in additional land clearing that leads to a release of GHG emissions (see box).

New biofuel technologies are under development — including fuels such as biobutanol and feedstocks such as cellulose (the leafy parts of plants), lignocellulose (the fibrous and woody parts), and waste — that may be able to improve fuel yield per acre and thereby produce biofuels with improved energy and GHG performance.

Biofuels production can have a range of other impacts on societies and ecosystems.

Other impacts resulting from large-scale deployment of biofuels include:

- *Food and feed supply*. Biofuels crops often compete with food and feed crops for land use, water, and other inputs, or are themselves food crops diverted from the table or stable to the fuel tank. Although the extent to which biofuels are directly implicated in rising food prices is debatable (many other factors are at play, including high energy costs, weather, market speculation, and the worldwide changes in diet driven by a rising middle class), biofuels demand has contributed to food price increases, precipitating protests by the urban poor in many countries.
- *Conservation*. Biofuel feedstocks are sometimes planted on lands that were previously important natural areas, damaging local ecosystems, displacing species, and impacting the livelihoods of the populations that depend on these ecosystems and species. Expansion of intensive agriculture can lead to ecosystem degradation in many ways. For instance, converting valuable ecosystems such as rainforests into monoculture crops for biofeedstocks destroys the habitats of many important species. Nutrient runoff from fertilizer application can make its way through the local watershed into major bodies of water, causing ecosystem damage there as well.
- *Rural incomes and distribution*. A significant part of the allure of biofuels in most countries is that they add a new income stream for rural communities.[9] This has certainly been the case, although in many instances concerns have been raised over the distribution of the economic benefits and over land rights. Particularly in tropical regions, the land on which agro-industrial companies expand their production may already be used by local people.

Deforestation and Climate Change

The Intergovernmental Panel on Climate Change (IPCC), the leading scientific body for climate science, estimates that deforestation accounts for 15-20 percent of GHG emissions globally.[1] Forests play a crucial role in the global carbon cycle, storing roughly half of the world's terrestrial carbon. When forests grow, they take up carbon dioxide from the atmosphere and sequester it as carbon in trees and soil. When forests are degraded or destroyed, such as by forest fires or logging, this carbon is released into the atmosphere, either immediately if the trees or the organic matter are burned or more slowly if it decays naturally. A small fraction of the carbon stored in the trees can continue to be stored in long-lasting wooden structures.[2]

Precise measurement of the carbon dioxide emissions from deforestation is difficult and depends on several factors, including the rate of deforestation and/or degradation, the carbon storage capacity of the forest in question (different kinds of vegetation can store different amounts of carbon), and the eventual use of the land once the forest is cleared. Despite the uncertainties surrounding exact measurements, it is clear that deforestation is a significant contributor to the accumulation of GHGs in the atmosphere.

Notes

1. World Resources Institute (WRI). 2007. *EarthTrends: Environmental Information.* Available at http://earthtrends.wri.org. Washington DC: World Resources Institute.
2. WRI *EarthTrends*, 2007.

The range of social and environmental impacts associated with today's biofuels means they are unlikely to make a major contribution to energy security and environmental goals until a new generation of biofuels and technologies emerges. In the near term, this may include new feedstocks for ethanol production, particularly biofuels from cellulose produced on marginal lands (i.e., lands that do not require clearing forests or displacing populations before planting crops), as well as new fuels. In the longer term, specially cultivated algae and the promise of various advances in biotechnology have excited the interest of researchers and investors. Even the "near term," however, may be further away than expected. The proprietary nature of many technologies makes progress hard to predict. Deploying next-generation biofuel technologies at scale will take time once they become commercially available, and even then there may be new environmental and social problems that have not yet been fully identified or explored. Even under fairly optimistic projections, the current problematic "first generation" feedstocks and fuels will dominate for years to come. A key policy question, then, is to ensure that biofuels do not cause more harm than good.

Creating the Right Incentives

Current policies support biofuels indiscriminately. Instead, policies should ensure that biofuels meet high environmental and social standards.

Biofuels policy has had mixed environmental results.

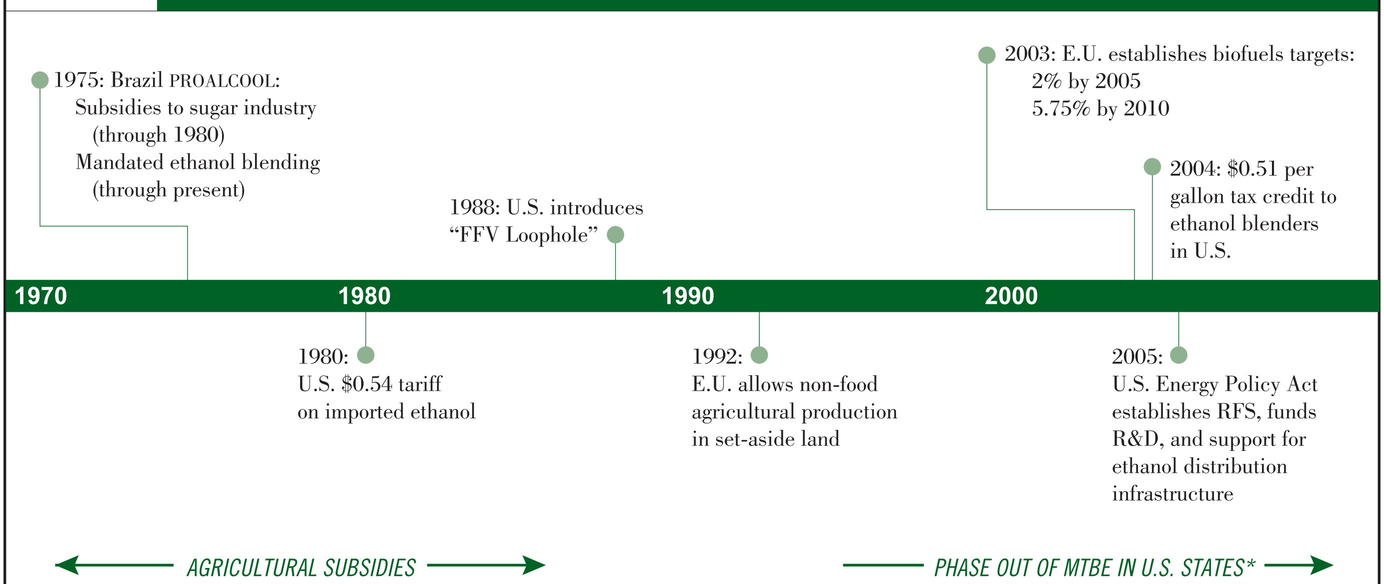
A wide range of policy support exists for biofuels deployment. In today's three main markets — Brazil, the E.U., and the U.S. — mandates dictate a given volume of biofuels consumption across the economy (see Figure 1). In some cases, policies prioritize certain biofuels products over others; for instance, cellulosic ethanol received double credit under the 2005 U.S. Renewable Fuel Standard (RFS). These mandates generally have targeted increased biofuels consumption rather than particular policy goals such as GHG reduction. Moreover, the mandates do not effectively mitigate other potentially negative consequences of expanded biofuels production, such as water quality impacts or biodiversity loss. The latest iteration of the RFS under the Energy Independence and Security Act of 2007 begins to set up an improved incentive structure by including lifecycle GHG performance standards for renewable fuels relative to petroleum-based fuels.

Since 1988, the Corporate Average Fuel Economy (CAFE) standards (the policy regulating vehicle fuel efficiency) have included a loophole designed to promote the production of ethanol-compatible "flex-fuel" vehicles to enable increased biofuels use to displace oil consumption. Ethanol is a less efficient fuel than gasoline, so in order not to penalize automakers for the reduced efficiency of the flex-fuel vehicles in their fleets, the loophole reduced the overall stringency of vehicle efficiency standards for companies that produce flex-fuel vehicles. However, as a result of this loophole, the petroleum fuel displaced by ethanol is more than offset by increased gasoline consumption of the less-efficient vehicles.[10] Recognizing this, Congress will be gradually phasing out this loophole under the Energy Independence and Security Act of 2007.

Today's biofuels program costs the U.S. government over $7 billion per year, including production tax incentives and direct subsidies for fuel and feedstock production from both the state and federal level.[11] However, oil consumption is roughly the same as it would have been if the U.S. had no biofuels policy at all. Moreover, in greenhouse gas terms, as discussed above, the lifecycle emissions from today's biofuels are actually higher than petroleum-based oil emissions.

In Europe, the E.U.'s biofuels policy has had another serious impact: it may be contributing to conservation policy decisions that lead to loss of habitat and carbon stocks.[12] A similar dynamic in the U.S. is emerging as farmers push to remove their lands from the Conservation Reserve Program early to

FIGURE 1 Timeline of Key Biofuels Policies



* Methyl tertiary-butyl ether (MTBE) is a chemical compound that has been used as a fuel additive in gasoline in the U.S. since the late 1970s. However, MTBE soon was found in groundwater and drinking water around the U.S., sparking an outcry. In response to these concerns, several states have banned MTBE and have begun using ethanol as a substitute.

take advantage of high crop prices. Still, for some producing countries there are real benefits: biofuels policy in Brazil has indeed put pressure on forests and agricultural markets, but has also undoubtedly played a major role in enhancing the country's energy security, raising rural incomes, and reducing foreign debt.[13]

Ideally, the right pricing structure should signal the market to prioritize the most efficient and environmentally friendly fuel and mobility choices. Within this framework, biofuels should be rewarded with policy support proportional to the specific benefits that they bring, such as life-cycle reductions in carbon dioxide emissions. As noted above, the new Energy Independence and Security Act takes a positive first step by incorporating GHG performance standards — fuels under the RFS must provide a 20 percent lifecycle reduction in GHG emissions compared to petroleum-based fuels. The methodologies for calculating these GHG benefits must be rigorously designed and implemented. And policy makers should avoid the temptation to undo the progress that these standards represent by relaxing them in the face of pressure from the ethanol industry over rising energy and food prices. Applying a technology-neutral "low-carbon fuel standard," rather than a technology-focused renewable fuels standard targeting increased production of today's fuels, can spur a number of technology solutions.[14]

Today's biofuels program costs the U.S. government over $7 billion per year.

Product standards and certification are needed to manage the social and environmental impacts of increased international trade in biofuels.

To date the three big biofuels markets discussed above have been largely geared to support domestic production. This means that impacts on water, soil, and air quality are governed by domestic regulation within those markets. However, as demand and mandates have grown beyond what domestic agriculture can provide, some countries have begun importing fuels and feedstocks, particularly from more productive regions (e.g., the tropics). As a result, some of the significant environmental and social impacts discussed above have been "exported" to these areas.

As this international trade in biofuels increases, there is growing interest in minimizing the negative impacts on other countries that can result from U.S. domestic biofuels consumption. The idea of biofuels certification, which would create market incentives for biofuels that have been produced in an environmentally friendly manner, has gained momentum, and several efforts are currently underway to ensure that fuel policies would exclude those that increase GHG emissions on a life-cycle basis from the fuel mix. For instance, California's Low Carbon Fuel Standard mandates a 10 percent reduction in the carbon content of California's transport fuels by 2020. The U.K.'s Renewable Transport Fuel Obligation (RTFO), which requires inclusion of biofuels and other renewable fuels in the U.K. fuel mix, includes a requirement that producers report the GHG balance and environmental impact of their biofuels. RTFO has established reporting guidelines for biofuels sustainability that attempt to lay the groundwork for practical application of such criteria. Several other major international initiatives exist, including the Roundtable on Sustainable Biofuels, the Global Bioenergy Partnership (GBEP), and the Roundtable for Sustainable Palm Oil (RSPO).

Conclusion

As biofuels production and consumption increase around the world, policy makers need to apply standards and regulations that ensure that biofuels support social and environmental objectives. Policy makers can no longer afford to support "biofuels" in general, as the term disguises a range of products with varying potentials to achieve policy aims. Measures to ensure high environmental and social standards throughout the lifecycle of the fuel, including certification, are essential to safeguarding the environment as well as the future of the biofuels market.

Although biofuels will likely play a major role in energy and agricultural policy in the years to come, today's policy structures and investments in biofuels are inadequate to address the challenges of a scaled-up biofuels industry and may actually do more harm than good. These policy design choices have not only negated the potential energy and emission benefits of biofuels, but have also impacted human welfare through higher food prices and damaged the environment through deforestation and more intensive farming. If allowed to continue, these impacts may produce a backlash sufficient to undermine public support for biofuels. Policy makers interested in the continued viability of the biofuels industry must ensure that their support fosters the development of a *sustainable* industry that protects livelihoods and ecosystems, improves energy security, and reduces GHG emissions.

Barring dramatic technological advances, biofuels alone will not address our low-carbon transportation needs. More serious efforts are needed to address climate change and energy

security in the medium term, probably through increased use of electricity for vehicle propulsion, accompanied by an aggressive rise in zero-carbon power generation. This drives home all the more the wisdom of basing policy on technology-neutral incentives to reduce carbon. While it may be possible for biofuels to help stabilize the climate, our current mix of policies is inadequate to ensure that they do.

Notes

1. This article summarizes and updates the conclusions of a report released by the World Resources Institute in December 2007. Please see Childs, Britt, and Rob Bradley. 2007. *Plants at the Pump: Biofuels, Climate Change, and Sustainability.* Washington, DC: World Resources Institute. Available online at: http://www.wri.org/publication/plants-at-the-pump.
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About the Authors

Britt Childs Staley is a research analyst in the Climate and Energy Program at the World Resources Institute. Her research focuses on international climate policy, specifically, policy frameworks to accelerate clean technology deployment. She holds a bachelor's degree in international politics from Georgetown University's Walsh School of Foreign Service.

Rob Bradley is Director of the World Resources Institute's International Climate Policy Initiative. Prior to joining WRI in 2004, he has worked for 10 years on European and international climate and energy policy for private, public, and NGO sector clients. He holds a BSc in Physical Sciences from University College London and an MSc in Environmental Sciences from the University of East Anglia.

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