GLOBAL DEVELOPMENT AND ENVIRONMENT INSTITUTE
WORKING PAPER NO. 15-01

Mandating Food Insecurity:
The Global Impacts of Rising Biofuel Mandates and Targets

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February 2015

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Abstract

Expanding demand for biofuels, fed significantly by government policies mandating rising levels of consumption in transportation fuel, has been strongly implicated in food price increases and food price volatility most recently seen in 2008 and 2011-2012. First-generation biofuels, made from agricultural crops, divert food directly to fuel markets and divert land, water and other food-producing resources from their current or potential uses for production of feed for animals and food for human consumption. A key policy driver of biofuel consumption is government mandates to increase or maintain rates or levels of biofuel blends in transportation fuel, the U.S. Renewable Fuel Standard and the E.U. Renewable Energy Directive being the most prominent cases. In this paper we assess the spread of such mandates and targets, finding that at least 64 countries now have such policies. We estimate the consumption increases implied by full implementation of such mandates in the seven countries/regions with the highest biofuel consumption, suggesting a 43% increase in first-generation biofuel consumption in 2025 over current levels. We compare this to even higher estimates from international agencies. We assess the likelihood of implementation in key countries and regions, which suggests that with reform, particularly in OECD countries, consumption growth could be slowed. We conclude with policy recommendations to reduce the mandate-driven expansion of first-generation biofuels and mitigate their negative social and environmental impacts.

Keywords: biofuels, agriculture, food policy, hunger, land use.

Mandating Food Insecurity:
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Timothy A. Wise and Emily Cole*

Executive Summary

Expanding demand for biofuels, fed significantly by government policies mandating rising levels of consumption in transportation fuel, has been strongly implicated in food price increases and food price volatility most recently seen in 2008 and 2011-2012. First-generation biofuels, made from agricultural crops, divert food directly to fuel markets and divert land, water and other food-producing resources from their current or potential uses for production of feed for animals and food for human consumption.

A wide range of international bodies, including the World Bank, the United Nation's Committee on World Food Security, and a landmark report prepared by G20 countries, has called for reforms to government policies that encourage the continued expansion of first-generation biofuel production. Unlike second-generation biofuels, which are less likely to compete with food crops for land and other resources, first-generation biofuels such as corn ethanol, soy and palm biodiesel, and sugarcane ethanol dominate the current global biofuels market.

In this paper, we document the global spread of the most widespread government support policies for biofuels: consumption mandates, with a particular focus on first-generation biofuels. These policies generally mandate the incorporation over time of a rising share or volume of biofuel into a country's transportation fuel. The U.S. Renewable Fuel Standard (RFS) is one such example, as is the European Union's (EU) Renewable Energy Directive (RED). Sixty-four countries now have biofuel mandates that reflect a wide range of ambition but that all encourage the use and usually the expansion of biofuel use.[1]

We show the current national and regional mandates (focusing on first-generation biofuels mandates) in place at this writing, assess the extent of their implementation based on available data, and estimate to the extent possible the implications of likely implementation. Using a range of projections from international agencies for comparison, we gauge the extent to which current mandates will expand future levels of biofuel consumption and production by 2025.

We find that the projected expansion of biofuels, and the resulting demands on food, land, and water, is indeed worrisome. Today we live in a world where two[2] to three[3] percent of transportation fuel is accounted for by biofuels (depending on the source one uses). Biofuels in the largest biofuel-producing countries, such as the United States and Brazil, comprise approximately 9% and 22% of gasoline and diesel blends consumed in each country, respectively, while most other countries' fuel supplies contain smaller percentages of ethanol and biodiesel.

* Timothy A. Wise is the Director of Policy Research and Emily Cole is a Researcher with the Global Development and Environment Institute at Tufts University. They would like to thank Sheila Karpf for her invaluable editorial assistance. The paper benefited from review by several experts, who remain nameless here. All errors are, of course, the responsibility of the authors.

The most commonly cited scenario from the International Energy Agency (IEA) projects a 150% increase in first-generation biofuel use by 2035. The agency estimates that 8% of transportation fuel (by volume) would come from biofuels,[4] with four-fifths of this expected to come from first-generation sources and just one-fifth from the assumed development of cellulosic ethanol and other second-generation biofuels produced from feedstocks that result in less competition for food and land.[5] IEA thus estimates that roughly 6% of transportation fuel would come from first-generation biofuels in 2035.[6]

Other international agencies estimate lower rates of expansion, and those are more consistent with our estimates based on current mandates and targets. The Organization for Economic Cooperation and Development and the UN Food and Agriculture Organization (OECD/FAO), for example, suggest a 50-60% increase in ethanol and biodiesel consumption over the next ten years.[7]

According to our estimates of global mandates for seven major biofuel-consuming countries (the United States, EU, Brazil, Argentina, China, India, and Indonesia), first-generation biofuel consumption could be expected to grow 43% over its current levels if existing mandates are fully implemented. This means the world would be blending 3-5% of first-generation biofuels into domestic fuel supplies by 2025.

These estimates are indeed worrisome, though they fall well short of the IEA estimates of a world with 8% of transportation fuel being derived from biofuels. This should bring little comfort to those concerned with the food, feed, land, and water demands of continued first-generation biofuel development. A 43% increase over current levels would likely require 13-17 million hectares more land than we are currently already devoting to biofuel production and approximately 145 billion more liters of water (assuming biofuels production requires roughly the same amount as current U.S. corn ethanol production).[8] A more detailed quantitative assessment of these impacts is much-needed to evaluate the specific impacts in different regions and countries under different scenarios.

What's more, the policies (and data) remain uncertain in several large developing countries, most notably China and India. We have good reason to believe that both will experience relatively limited expansion of first-generation biofuel use, but any large-scale commitment to first-generation biofuel development in these countries would have a dramatic and devastating impact, whether the feedstocks or fuel are sourced domestically or imported.

In addition, we find:

Mandates Are Key Drivers

- The number of countries with consumption mandates has risen to 64 and is continuing to grow.
- OECD mandates will continue to be the real drivers of biofuels demand, with the United States and the European Union projected to account for roughly 60% of global biofuel consumption in 2025, and nearly 50% of projected new biofuel consumption.
- Most mandates are based on percentage shares of consumption, rather than volumes as in the United States. The mere growth in demand for transportation fuels, due to economic growth

and the rise in the prevalence of private automobiles, particularly in large, fast-growing developing countries, can be expected to account for a 16% rise in biofuel consumption over current levels.

- An oversupply of palm oil production in supplier countries like Indonesia, partially caused by EU mandates, has contributed to more ambitious consumption mandates in Indonesia.[9] Indonesia shows the most ambitious targets and the most dramatic growth in first-generation biofuel consumption among developing countries, contributing to an already-serious deforestation problem.
- Full implementation of mandates is by no means certain. In India, for example, ethanol targets were recently scaled back from 20% to 5% because the country has lagged in sugar production to provide the necessary feedstock. India is now blending only about 2% ethanol into its transportation fuel supply. India also has a 20% biodiesel target, but there is good reason to doubt it will meet such a goal.[10]

Trade is a Major Driver

- Brazil is a major producer and consumer. Economic growth will drive rises in domestic consumption, but ethanol exports are also expected to increase depending on market and trade conditions. The United States is also seeking to expand its ethanol exports.
- Mandates are driving growing ethanol trade, in perverse ways. Brazilian sugar ethanol is imported by the United States to fulfill its mandates for advanced biofuels, while the United States has sometimes exported corn ethanol to Brazil to make up for losses to the Brazilian domestic market.
- Prior to Dec. 2011 when the U.S. ethanol tax credit and tariff were eliminated, Caribbean Basin Initiative (CBI) countries received preferential treatment in the U.S. ethanol market. The Central American Free Trade Agreement allowed Brazilian ethanol to be dehydrated in CBI countries and then exported to the United States.[11]

Significant Technological and Policy Uncertainty

- China is the biggest wild card in these projections. With a mandate that covers just nine provinces now, China is blending only 1.1% biofuel into its transportation fuels, and that is not expected to grow appreciably. The government has been sensitive to the food-fuel competition in its policies to date, but the country's demand for transportation fuel is projected to grow dramatically, creating strong incentives for the government to promote consumption. Any expansion of China's biofuel consumption would have global repercussions, particularly if China relies on imported feedstock or fuel to meet such mandates.
- The emergence of potentially more sustainable non-food-based, second-generation biofuels and implementation of sustainability standards could alter these estimates considerably if the technology and commercial applications proceed more quickly than currently projected. Public research and incentives for second-generation biofuels may help jumpstart the industry beyond its current small scale, but much is still unknown.
- Second-generation biofuels could be no better than first-generation fuels if they displace land or other resources from other productive uses.

Recommendations

Our analysis suggests the need for governments to cease the implementation and expansion of current food-based biofuels consumption mandates and to forgo the creation of new mandates. Mandates prop up demand for biofuels, particularly at times when oil prices are relatively low. Governments and international bodies should also eliminate perverse incentives such as biofuels subsidies for first-generation biofuels that impact the food supply.

Proposed reforms to U.S. and EU mandates are welcome and needed. The EU proposal to limit first-generation biofuels to 7%, within the EU's 10% mandate, would reduce the EU's contribution to global biofuel expansion by 50%.

The United States would do well to consider similar reforms. The United States is expected to remain by far the largest global consumer of first-generation biofuels in 2025, contribute the most to global consumption, and do so using the feedstock – corn – that provides the fewest environmental benefits and most directly competes with food and feed markets. Even a modest reform, such as that proposed by the Environmental Protection Agency in 2013 to scale back the mandate, would reduce projected consumption growth in 2022 by one-third.

Mandates must be scaled back further, and strict sustainability criteria must be applied to mandates for both first and second-generation biofuels. Otherwise, governments are mandating not just biofuel consumption but hunger and unsustainable resource use.

The full paper is available at:
http://www.ase.tufts.edu/gdae/policy_research/BiofuelMandates.html

I. Introduction

Expanded demand for biofuels, fed significantly by government policies mandating rising levels of consumption in transportation fuel, has been strongly implicated in the recent rise and volatility in global food and feed prices.[12] First-generation biofuels, made from agricultural crops, divert food directly to fuel markets and divert land, water and other food-producing resources from their current or potential uses for production of feed for animals and food for human consumption. First-generation biofuels produced from input-intensive and food-based crops have been tied to food and feed price increases, increased greenhouse gas (GHG) emissions for certain fuels, land rights disputes in developing countries, conversion of native grasslands and wetlands to biofuels crops, and other unintended consequences.[13]

Unlike some second-generation biofuels, which are less likely to compete with food crops for land and other resources, first-generation biofuels such as corn ethanol, soy and palm biodiesel, and sugarcane ethanol dominate the current global biofuels market. When the biofuels industry was in its infancy, its proponents promised that second-generation biofuels would come on line in a few years and food versus fuel concerns would wane as perennial grasses, agricultural residues (such as corn stalks or cobs), and wood residues would be used for cellulosic ethanol production.[14] However, cellulosic ethanol production is failing to reach large-scale commercial production, and hence, biofuels produced around the world are failing to meet high levels of GHG emissions reductions that were once promised. New estimates suggest, for instance, that corn ethanol production in the United States may actually contribute to greater carbon emissions than gasoline.[15]

The biofuels industry seeks additional expansion of both first- and second-generation biofuels production. Agribusinesses and biofuels lobbying organizations have pushed for biofuels expansion in countries that currently have large biofuels mandates – most notably Brazil, the European Union (EU), and the United States – and in others where biofuels mandates have yet to be filled or greatly scaled up such as in India and China.[16]

In this paper, we document the global spread of the most widespread government support policies for biofuels, consumption mandates. Sixty-four countries now have biofuel mandates that reflect a wide range of ambition but that all encourage the use and usually the expansion of biofuels.[17] These generally mandate the incorporation over time of a rising share or volume of biofuel into a country's transportation fuel.

The three largest mandates include the U.S. RFS, Brazil's ethanol and biodiesel mandates, and the EU's RED. U.S. demand for ethanol has expanded drastically since 2007, partially a result of subsidies and the RFS mandate but also its use as an oxygenate additive as a replacement for lead. The mandate rose from 11BL a decade ago to nearly 53BL today. Brazil, a country with the oldest global ethanol mandate of 25% ethanol (E25), consumed 24BL of ethanol in 2014.[18] Responding to recent concerns about food vs. fuel, the EU proposed a cap on the amount of biofuels that can be derived from food crops at 7%, out of its 10% biofuels mandate, by 2020. The EU currently consumes about 19BL of biofuels, and most member states will expand consumption further to meet both the 7% proposed food-based biofuels cap and the 10% overall mandate.

We show these and other national and regional mandates in place at this writing, assess the extent of their implementation and likelihood of fulfillment based on available data, and estimate to the extent possible the implications of implementation on global land availability and water use. Using a range of projections from international agencies for comparison, we gauge the extent to which current mandates will expand future levels of biofuel consumption and production by 2025.

Today we live in a world where two[19] to three[20] percent of transportation fuel (depending on the source one uses) is comprised of biofuels. Biofuels in the largest biofuel-producing countries, such as the United States and Brazil, comprise approximately 9% and 22% of gasoline and diesel blends consumed in each country, respectively, while most other countries' fuel supplies contain a smaller percentage of ethanol and biodiesel.

The most widely cited scenario from the International Energy Agency (IEA) suggests a 150% increase in first-generation biofuel use by 2035, with 80% derived from non-cellulosic fuel.[21] This demand increase would mean that the world's transportation fuel supply would be comprised of 8% biofuels in 2035, with 6% from first-generation biofuels.[22]

Other international agencies estimate lower rates of expansion, which are in line with our estimates of demand growth. The Organization for Economic Cooperation and Development and the United Nation's (UN) Food and Agriculture Organization (OECD/FAO), for example, suggest a 50-60% increase in ethanol and biodiesel consumption over the next ten years.[23] Considering current levels of implementation of existing mandates and projections from these and other institutions, it is clear, even with the most conservative estimates, that first-generation biofuels production and consumption will grow significantly over the next one to two decades with significant implications for the environment, food prices, and the livelihoods of people around the world.

II. Background

Biofuels include all fuels made from organic matter. In this paper, we focus on biofuels that can be used for transport, specifically ethanol and biodiesel, and more specifically so-called first-generation biofuels, which are made from food or feed crops. While many of the concerns presented in this paper are equally true of biomass used for electricity production, biomass has not been explicitly included in our estimates and analysis.

A biofuels feedstock is the organic material that is used to make the ethanol or biodiesel. Different countries produce and consume biofuels from different feedstocks with different environmental and social impacts. The principal feedstock in the United States is corn for ethanol. In the EU it is biodiesel made from vegetable oils such as palm oil. Brazil relies on sugar for ethanol. While every feedstock may have an appropriate use, at high volumes they all can have unintended consequences, especially those that are in limited supply. For example, used cooking oil is a feedstock for European biodiesel, which would otherwise go to waste. But heavy demand for used cooking oil is increasing demand for virgin cooking oil such as from African palm, in effect feeding a competition between fuel and food.

Biofuels: Defining Terms

The terms "first- and second-generation biofuels," "conventional ethanol," "advanced biofuels," and "cellulosic ethanol" are used throughout this paper. Below is a definition of each as it is used here:

First-generation biofuels: ethanol and biodiesel produced from crops such as corn and sugarcane (for ethanol) and palm oil, soybean oil, rapeseed oil, used cooking oil, and other vegetable oils (for biodiesel), which are largely also used as food and feed crops. These biofuels have been produced for decades, especially in the case of Brazil with sugarcane ethanol and the United States with corn ethanol.

Second-generation biofuels: ethanol or biodiesel produced from largely non-food feedstocks such as perennial grasses, wood and agricultural residues, algae, etc. While these could potentially result in less competition with the food supply, second-generation biofuels have yet to be produced at large commercial scales so their effects on land use, water supplies, food security, and GHG emissions are still little known.

U.S. Renewable Fuel Standard categories: The U.S. RFS, enacted in 2005 but expanded in 2007, mandates that the U.S. fuel supply contain 138 billion liters (BL) of biofuels from three different biofuels categories by 2022. Note that these categories differ from those of first- and second-generation biofuels listed above, meaning that even though our analysis focuses on first-generation biofuels, the United States considers some first-generation biofuels such as sugarcane ethanol to qualify as an "advanced" biofuel. Terms used in the U.S. case include the following:

- **Conventional ethanol:** the "renewable fuel/conventional ethanol" category in the RFS requires ethanol to meet a 20% GHG reduction threshold although most facilities were grandfathered into this category, meaning they may actually *increase* GHG emissions; conventional ethanol is mostly comprised of corn ethanol.
- **Advanced biofuels:** biofuels that meet a 50% GHG reduction threshold; types of approved advanced biofuels include soy biodiesel, biodiesel from other vegetable oils and animal fats, cellulosic ethanol (see below), and sugarcane ethanol.
- **Cellulosic ethanol:** cellulosic biofuels that meet a 60% GHG reduction threshold and are derived from cellulosic feedstocks such as perennial grasses and wood or agricultural residues.

In 2011, the global biofuels market was worth $83 billion—roughly the size of the world coffee market.[24] The global biofuels market tripled between 2000 and 2007.[25] More recently, between 2009 and 2011 the market doubled again.[26] Today 2-3% of global transportation fuel is from biofuels.[27] A global commodity, biofuels is heavily traded across the globe with some countries both exporting and importing biofuels.

Social and Environmental Costs

Sizeable percentages of food crops are diverted to biofuels production now and will continue to be diverted in the future, with implications for food security. According to FAO-OECD projections, by 2023, 12% of maize and other coarse grains will go to biofuel production, while 14% of global vegetable oils will be used to produce biodiesel; for sugar, 28% will go into the production of transportation fuels.[28] During the recent 2008 food price crisis, 20-40% of the food price increases were attributed to biofuels.[29]

An October 2012 GDAE/ActionAid report found that corn-importing countries paid $11.6 billion in higher corn prices due to U.S. ethanol expansion from 2006 until 2011, $6.6 billion of which was borne by developing nations where much of the population already spends 60-80% of their income on food.[30] A May 2012 GDAE/ActionAid report estimated additional import costs to Mexico in particular, in the form of higher corn prices due to U.S. ethanol expansion, of at least $1.5 billion since 2004. Increased corn prices reduce purchasing power for consumers and can offset international aid dollars sent to developing countries for food and agricultural programs.[31]

Many international agencies have called for reforms to government policies that encourage the continued expansion of first-generation biofuel production. In 2008, the former head of the World Bank, Robert Zoellick, called on countries to reform biofuels mandates due to negative impacts on food security.[32] In 2011, a report commissioned by G20 agricultural ministers, recommended that countries "remove provisions of current national policies that subsidize (or mandate) biofuels production or consumption," acknowledging that biofuels production was a significant factor in increased food prices and food price volatility.[33] And in 2013, the UN Committee on World Food Security's (CFS) High Level Panel of Experts report on biofuels noted that "biofuels and more generally bioenergy compete for land and water with food production"; it recommended an additional set of guidelines be created to evaluate the viability of national biofuels policies based on the impact of said policies on access to land and on international food security.[34]

The environmental benefits of biofuels have also been called into question. Land used to grow biofuels crops is often converted from non-food uses, such as forests, adding to the environmental issues associated with deforestation. In Indonesia, for example, overall forest losses (due partly to palm oil expansion) have been projected as high as 6 million hectares from 2000 to 2012.[35] A recent study from the journal *Nature Climate Change*, estimated that by 2012 Indonesia was losing primary forests at a rate of 840,000 hectares per year, higher than losses in Brazil. (The Indonesian government, however, has reported significantly lower rates of deforestation to the UN – approximately 400,000 hectares annually between 2009 and 2011.)[36] As the World Resources Institute notes, "although the evidence of destruction is mounting, the picture has been muddied by conflicting data, disinformation, claim and counterclaim."[37] The Rainforest Action Network reports that Indonesia is the "third largest emitter of global warming emissions after China and the United States, with 85% of its emissions profile coming from deforestation and drainage of peatlands [of which palm oil is a major driver]."[38]

Two of the original goals for biofuel development in the EU and United States in particular were to increase energy independence and to reduce GHG emissions in the transportation sector. The

case for each has gotten weaker over time. As one IEA study puts it, "It is increasingly understood that 1st–generation biofuels (produced primarily from food crops such as grains, sugar beet and oil seeds) are limited in their ability to achieve targets for oil-product substitution, climate change mitigation, and economic growth."[39] In 2011, the National Academies of Science concluded that first-generation biofuels such as corn ethanol are failing to significantly reduce GHG emissions in part due to indirect land use change, and that cellulosic ethanol production in the United States is unlikely to reach a large commercial scale due to technological and economic challenges.[40]

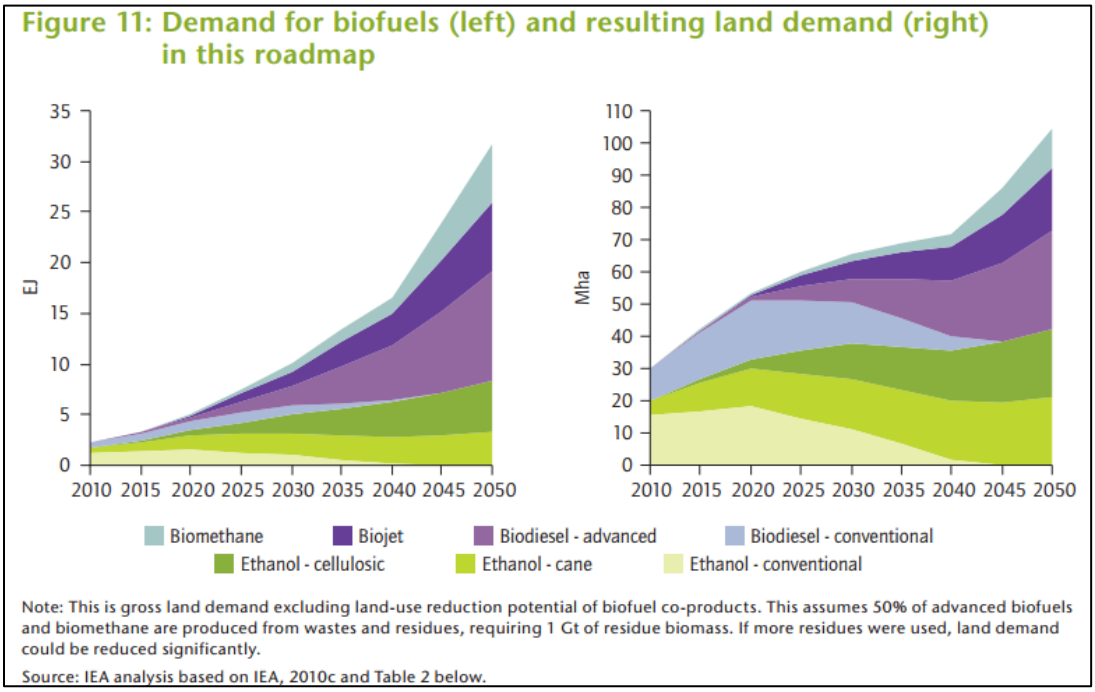
Other first-generation biofuels may result in GHG emission reductions, but figures vary primarily due to different calculations of emissions from indirect land use change. For instance, when corn in the United States is diverted from the feed supply to biofuel production, for instance, additional feed crops must be produced elsewhere which can lead to farmers tearing up native grassland and draining wetlands to create more arable farmland. Cropland dedicated to other food and feed crops (oats, barley, alfalfa, etc.) has decreased in countries such as the United States, Guatemala, and Brazil as demand for corn, sugar, and soybean cropland rose over the past several years.[41]

Cellulosic biofuels, a specific type of second generation biofuel, may offer significant GHG benefits and could have more limited impact on land use. Cellulosic biofuels are also expected to lead to fewer food-versus-fuel impacts associated with first-generation biofuels. However, some next-generation biofuels recently proposed in the United States, such as corn biobutanol, would still be produced from food-based crops. Second-generation technologies are under development, and they are not expected to be commercially viable in a significant way by 2025.[42]

Even organizations that are bullish on the use of biofuels, such as the IEA, recognize the land demands for their future biofuels scenarios. Each exajoule (EJ, 10^{18} joules, a unit of energy used at the industrial production level) of energy created requires about 10 million hectares of land. (See Figure 1)[43] It is worth noting that the land-intensity estimates even for second-generation biofuels remains significant (about 3 million ha/EJ), raising questions about their sustainability.

Estimates vary, but according to the FAO, an estimated 2-3% of arable land is devoted to biofuels production.[44] FAO estimates "an equivalent of 20.4 million [hectares (ha)] of sugar cane, or 38.5 million ha of corn, or, if it were biodiesel, 58.8 million ha of rapeseed" are now used in biofuels production worldwide.[45] In the developed world and emerging economies, the energy and land use investments in biofuels vary dramatically. For example, in the United States, 37% of the corn crop is diverted to ethanol production (but one-third of this corn ends up as livestock feed via a by-product called distiller's grain).[46] In the UK in 2011, 1.8% of all farmland was dedicated to growing crops for ethanol,[47] but it also relied upon imported biofuels and biofuel feedstocks from other countries to meet its mandate.

Figure 1[48]



In developed countries and in emerging economies, biofuels production may cause relatively little social disruption, environmental and land use implications aside. In the developing world, however, the demands of biofuels production are much more likely to disrupt the local population and economy.[49] In some countries, such as India and Thailand, there is already great pressure on cropland. Expanding biofuels production in these countries, from any feedstock, would have additional impacts on land use. Countries such as Brazil have systems in place to reduce direct and indirect land use change.[50] However, these systems have not necessarily been effective since soybeans have instead been planted in areas with restrictions on new sugar plantations.

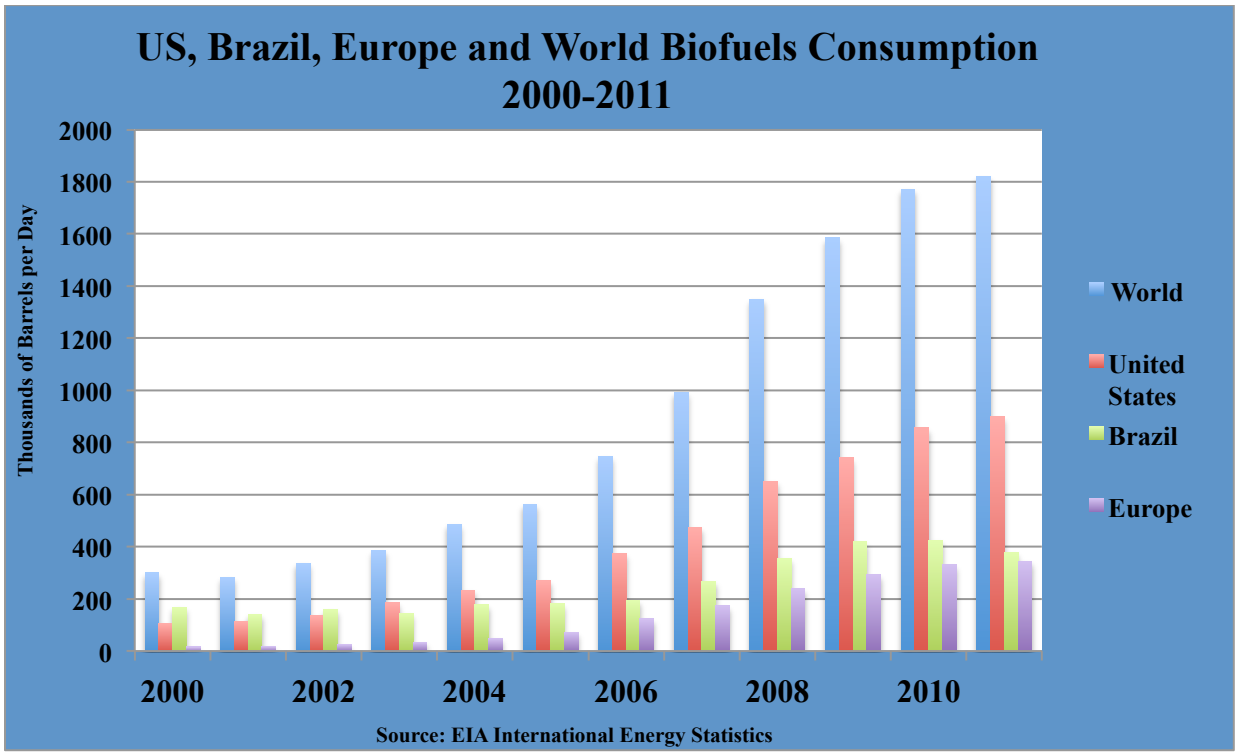
In other countries such as Ethiopia where there are already large-scale land acquisitions and significant displacements of people due to foreign investments in land projects and "villagization," large-scale biofuels projects are yet another threat to rural communities' livelihoods, food security, and human rights. (See Appendix C for list of existing and planned biofuels projects in Ethiopia). In other African countries such as Tanzania, the land rush for biofuels and other agricultural production has resulted in vast tracts of land being sold or leased to commercial interests, many of which are large multinational biofuels companies or agribusinesses aiming to export biofuels to the EU and other countries with large biofuels mandates. Local communities lose land previously used for farming, animal grazing, fishing and gathering wild foods, as well as for wood and water collection, when land deals prioritize investors and outside interests over local livelihoods.

Key Players

While 64 countries have biofuels mandates or targets, global production and consumption of biofuels is driven principally by a few countries. The United States is responsible for 43% of global production of biofuels.[51] Brazil, the second largest producer, provides 26% of global production.[52] Germany (4.9%), France (3.9%), and Spain (2%) round out the top five biofuel producers.[53]

OECD countries are the largest consumers of biofuels and drive biofuels production within their own borders and across the world.[54] As Figure 2 shows, biofuels consumption has increased dramatically since 2000. By 2011, world use had increased 500% with the largest increases coming in the United States.

Figure 2[55]



Focus on Mandates

While subsidies have also played a large part in the development of biofuels industries, the primary focus of this paper is biofuels mandates, as they are the primary government support across countries. Mandates provide security for investors knowing a market for their goods will continue over their investment period, and they drive the development of fuel distribution networks, such as the blending of ethanol into gasoline and its storage and dispensing at fueling stations.

Mandates can take one of two forms. The first, a consumption mandate, requires a certain volume of biofuels to be blended with gasoline and diesel each year. This is the type of mandate

that exists in the U.S. RFS.[56] The more common form of mandate requires that a certain percentage of transport fuel consist of ethanol or biodiesel. This is the form of mandate used in the EU[57] and most other countries.

Countries have pursued biofuels policies for many seemingly worthwhile goals:

- Promoting energy security
- Reducing dependence on fossil fuels
- Supporting rural communities, smallholder farmers and rural development
- Reducing GHG emissions and accessing a low-carbon transportation fuel (particularly the EU)
- Improving the nation's trade balance or balance of payments by reducing oil imports
- Promoting national self-sufficiency

In the OECD, these policies were mainly crafted in the early 2000s. In hindsight, mandates were overly optimistic with respect to technical, infrastructure, and market challenges. It is now apparent that biofuels mandates failed to predict future negative impacts on land use, GHG emissions, food security, and rural communities. GHG emissions reductions have been found to be more limited than first thought, indirect land use changes are now understood to be significant, and with high crop prices in 2011-2012 farmers and consumers alike have dealt with higher and more volatile crop and food prices. In the EU and United States in particular, these changes have led to recent proposed policy reforms and ongoing debate over the value of biofuels use.

In other countries, the motivating factors above remain strong. For some countries, such as South Korea, the world's fifth largest oil importer, the pressure to diversify its energy mix for security and economic reasons may outweigh the higher cost and social and environmental impacts of biofuels consumption.[58] Indonesia is a similar story.

Many developing countries have followed the OECD's lead in instituting biofuels mandates. These countries have pursued biofuels policies to show their commitment to fighting climate change and advancing energy security, but also to spur rural development, support the agricultural sector, and move up the agricultural value chain. In addition these policies provide subsidies for particular industries (sugar in India, for example). In Southeast Asia, Malaysia and Indonesia have recently increased domestic biofuels mandates to counteract deteriorating export opportunities as a result of anti-deforestation policies taken by buyers such as the EU. Utilizing more palm oil for biofuels increases demand for the feedstock, increases farm-gate prices, and reduces the amount of diesel that must be imported for consumers. Countries have looked to biofuels both to reduce their dependence on expensive foreign oil but also to create an export industry that could help provide a source of foreign exchange.

The notable exception to this typology is Brazil, the country with the oldest and most fully developed biofuels sector. In the 1970s, Brazil invested heavily in producing ethanol from sugar cane in response to high international oil prices, leading to its position as a leader in the biofuels market, particularly for ethanol.[59]

From biofuels producers to large landholders, every country producing biofuels has much at stake if biofuels mandates are reduced or eliminated, although some biofuels would still be

blended (for use as an oxygenate, for instance). This is widely seen as one of the reasons biofuels policies have been so slow to respond to high crop prices and social and environmental concerns.

Government Supports for Biofuels

Major biofuel-producing countries – including Brazil and the United States - have relied on mandates and subsidies to build their biofuels industries. These incentives span the supply chain, from feedstock production to final blending of biofuels with gasoline or diesel. European biodiesel is also subsidized, and cost-competitive because of the significantly higher cost of gasoline in the EU. In France, the estimated cost of biofuels subsidies for 2011 only was between €170 million and €210 million for ethanol and almost three times that amount for biodiesel—between €612 million and €800 million.[60] But it is also the case that in other markets like Indonesia, the drain on national budgets from fossil fuel subsidies makes the mobilization of homegrown feedstocks – in this case, palm oil – a more attractive proposition. Fossil fuel subsidies themselves distort markets, and layering biofuels subsidies on top of them creates large national expenditures and several unintended consequences as certain fuels are prioritized over others.

As the IEA has noted about the rise of biofuels, "The rapid growth of the biofuels industry would not have been possible without government subsidies because many biofuel producers, especially in developed countries, are not cost competitive."[61] The story of biofuels expansion is, therefore, a story of subsidies and mandates. Using the United States as an example, its ethanol and biodiesel industries were propelled by decades of subsidies for production and blending with gasoline and diesel, import tariffs, and the RFS mandate which was enacted in 2005 but greatly expanded in 2007. While the largest tax credits for ethanol and biodiesel have expired, the biodiesel and cellulosic tax credits and other credits such as those for biofuel infrastructure investments are routinely extended, and other smaller supports in various government agency programs continue to prop up the industry.

III. International Biofuels Production and Consumption Estimates

Before presenting our assessment of current mandates and what they would mean for global biofuel demand, we present some of the most important projections from international organizations. They vary in their assumptions, methodologies, and time horizons, but all confirm that we are likely to see significant expansion in biofuel consumption for at least the next ten years. The estimates range from a low of 50-60% growth in demand by 2023, to a high of 150% by 2035. Below, we examine estimates from the International Energy Agency (IEA), the OECD/FAO's Agricultural Outlook, and the U.S. Energy Information Agency (EIA).

Each agency makes assumptions about the key drivers of biofuel demand, both in terms of government policies and market-based factors. All attempt to incorporate announced government policies, though it is difficult to keep up with the ever-changing policy environment. Any projections of 10-20 years into the future will be sensitive to assumed growth rates in key drivers, and such differences in assumptions explain the variation in these estimates.

Transportation fuel demand will be a primary driver of biofuels consumption, especially in fast-growing developing countries such as China and India, but also in areas with mandates for biofuels blending by percentage of transportation fuel. (The blending percentage can stay the same but the effective demand increases with the growth in the market unless fuel efficiency increases, thus reducing the level of fuel demand.) This consumption will be driven by:

- *Population Growth*: with economic growth and economic growth, population growth, especially in emerging markets, will be a key driver of transportation fuel demand.

- *Economic Growth (world, nation, per capita)*: as countries become more affluent, they drive more, demanding more transportation fuel.

- *Number of Miles Driven*: While the United States does not serve as a good model for the rest of the world, recent reductions in number of miles driven show the uncertainty in predicting future patterns of consumption.

- *Fuel Efficiency Standards and Vehicle Technological Change*: changes in transportation technology such as hybrid cars, electric cars, E15- and E85-ready cars and increased fuel efficiency standards will also affect demand. Radical, global change in fuel efficiency could temper demand growth. Consumer uptake of E15, E85, and other higher ethanol blends, stations offering higher blends of ethanol, and availability of flex fuel vehicles also affects consumption, particularly in the United States

- *Broader Energy Markets:* decisions made about broader transportation planning affect demand, including reliance on electrification, commitments to mass transit, and alternative forms of transport.

Other key drivers of biofuels demand include:

- *Oil Prices*: when deciding whether or not to substitute some petroleum consumption with biofuels, the relative prices of these goods is paramount. As petroleum prices are notoriously difficult to predict, oil prices in particular may pose a problem for complex modelers looking several years in the future. In addition, petroleum is an input for first generation biofuel feedstock that is grown with petroleum-based fertilizers. As an input, as oil prices increase, the price of biofuels may also rise. The effect on their relative prices will be a key biofuels demand driver, factoring in subsidies and mandates, which affect prices.

- *Food and Fiber Prices*: like oil prices, the prices of food and fiber will determine whether or not biofuels consumption is economically viable. First generation biofuels are not only competing with food and fiber for land, fertilizer and water, but are produced from food and feed products themselves.

- *GHG Emissions Pricing Schemes*: in the estimates cited here from the IEA, EIA and OECD/FAO, carbon markets and the assumption of a carbon savings from biofuels are key to their continued expansion.

- *Speed of Technological Change in Biofuels*: technological changes and commercial adoption of these technologies are built into IEA and other models projecting increased demand. For years, the biofuels industry promised cellulosic fuels would be commercially viable, but they have been slow to develop due to technological and economic challenges. In the U.S. 2007 energy bill, for instance, policymakers mandated 6.65BL of cellulosic ethanol to be blended with gasoline in 2014, but only 65 million liters (barely 1% of the mandate) are expected to be produced. Whether and how quickly such industries develop will determine a great deal about first-generation biofuel growth.

International Energy Agency Projections

The International Energy Agency (IEA) makes several energy consumption estimates in its *World Energy Outlook* each year. The estimates below are drawn from its 2013 report. The IEA uses three policy scenarios to make its projections.

1. *New Policies Scenario*: this is the most commonly cited set of global projected-demand numbers in research and policy circles. It models "cautious implementation of existing policies," meaning it accounts for policies that are currently in place and assumes the implementation of announced policies. [62] It is the scenario IEA believes reflects the most likely future.

2. *Current Policies Scenario*: this very conservative scenario considers only policies that were in place by mid-2013.

3. *450 Scenario*: the 450 Scenario considers "an energy pathway compatible with a 50% chance of limiting the long-term increase in average global temperature to 2 degrees Celsius."[63]

Biofuels consumption is assumed to increase based on economic and population growth, reductions in fossil fuels subsidies, and a modest increase in petroleum prices. In addition, all three scenarios assume a GHG benefit from biofuels use, although the importance given to GHG reductions as a demand parameter is different in each scenario. In these models, biofuels would have an added economic benefit in carbon trading schemes or with the enactment of a carbon tax making them significantly more price competitive with fossil fuels, although actual GHG emission reductions seen on the ground may differ from projections.

New Policies Scenario

The New Policies Scenario assumes an average rate of GDP growth of 3.6% per year until 2035.[64] It also assumes non-OECD GDP will surpass OECD GDP as early as next year,[65] with strong growth rates for China (5.7%)[66] and India (6.3%)[67] through 2035. Moreover, IEA assumes world population will reach 8.7 billion by 2035 and that 62% of the population will live in urban areas.[68] At the same time, this scenario assumes only modest increases in oil prices from $110/barrel in 2011, $113/barrel in 2020 and $128/barrel in 2035.[69] More than 175 countries currently have fossil fuel subsidies, which the IEA sees declining in the next 20 years, making biofuels more economically competitive.[70] IEA also assumes that China will stick to its goal of

reducing its dependence on coal and that India will meet its current 5% ethanol mandate and continue to blend 5% ethanol even as gasoline demand increases.

In line with industry and other academic and governmental predictions, IEA finds "the U.S., Brazil, EU and China make up more than 80% of biofuels demand."[71] By 2035, OECD countries will make up a little under half of biofuels consumption.[72] IEA predicts China will drive growth in biofuels until 2020 when consumption will be driven by India, whose population will be surpassing China and Southeast Asian countries.

The New Policies Scenario assumes an initial increase in energy demand of 1.6% per year, which slows after 2020 to an average of 1%.[73] In this scenario, therefore, there will be a 33% increase in total energy demand by 2035.[74] Energy demanded for "transport grows at an average rate of 1.3% per year over the projection period," with the majority of growth coming from non-OECD countries.[75]

Bioenergy investments are expected to outpace energy demand in aggregate and are thus expected to represent a larger share of total transport-sector demand by 2035. Specifically, IEA predicts a 1.5% annual increase in investments in bioenergy—both biofuels and biomass.[76] This growth is small compared to other renewables (7.3%),[77] but represents a dramatic and persistent increase in production. IEA expects biofuels production to account for only 5% of the increased investment in renewables.[78] However, projections on investment as opposed to production are highly speculative.

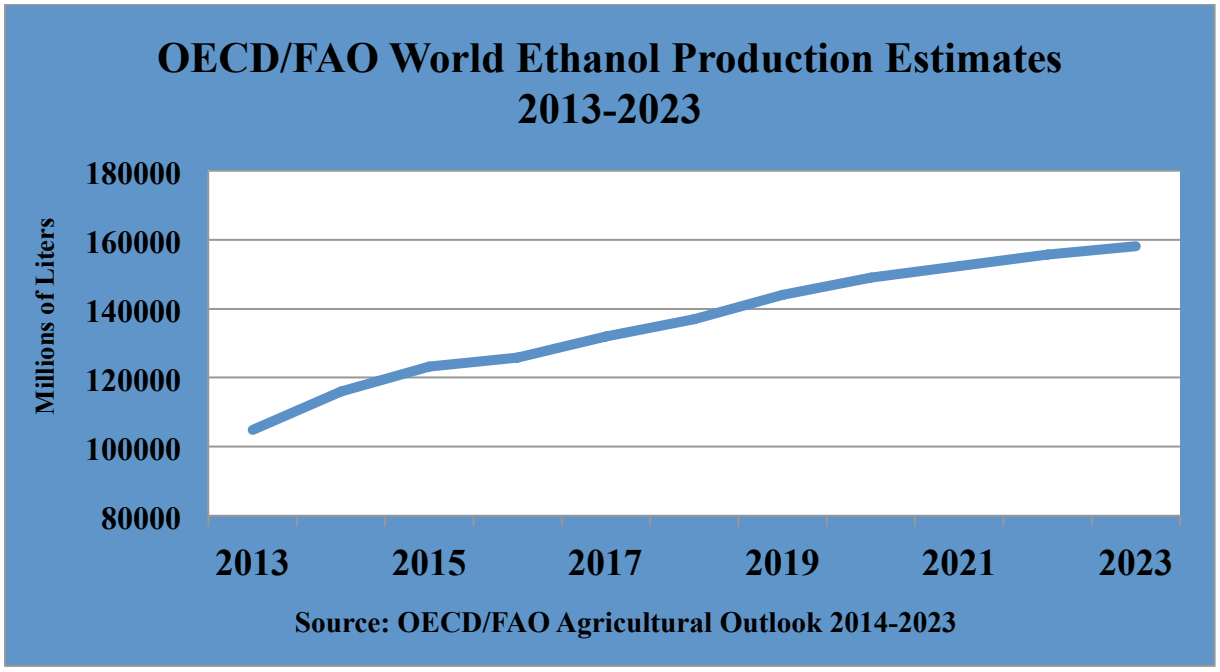
In terms of volumes, IEA predicts consumption of biofuels will increase from 1.3mboe/d in 2011 to 4.1mboe/d in 2035.[79] This aggressive projection predicts 8% of road-transport fuel demand in 2035 will come from biofuels.[80] Yet, they predict that*, even in 2035,* 80% of that fuel will still come from first-generation biofuels, with just 20% coming from cellulosic or other advanced fuels.[81] (Note that the IEA definition of "advanced" may not align with the RFS definition as IEA does not consider sugar ethanol to be advanced).

OECD/FAO Projections

The OECD, established in 1961 to "promote policies that will improve the economic and social well-being of people around the world," predicts an overall increase in global biofuels production but a smaller share in percentage terms represented by demand in OECD countries.[82] OECD countries include the world's richest and the top two biofuels producers in the world – the United States and EU – but also emerging countries like Mexico, Chile and Turkey. The OECD also works closely with emerging economies such as Brazil and those that may greatly influence biofuels markets in the future – China and India.[83]

The OECD, in its annual *Agricultural Outlook* report with the FAO, projects a 50% increase in world ethanol production between 2013 and 2023 with production jumping from 105BL to 158BL.[84] It also finds biodiesel consumption will rise from 26BL in 2013 to 40BL in 2023—a 54% increase over 2013 consumption.[85] The projected expansion in world ethanol production is shown below.

Figure 3[86]



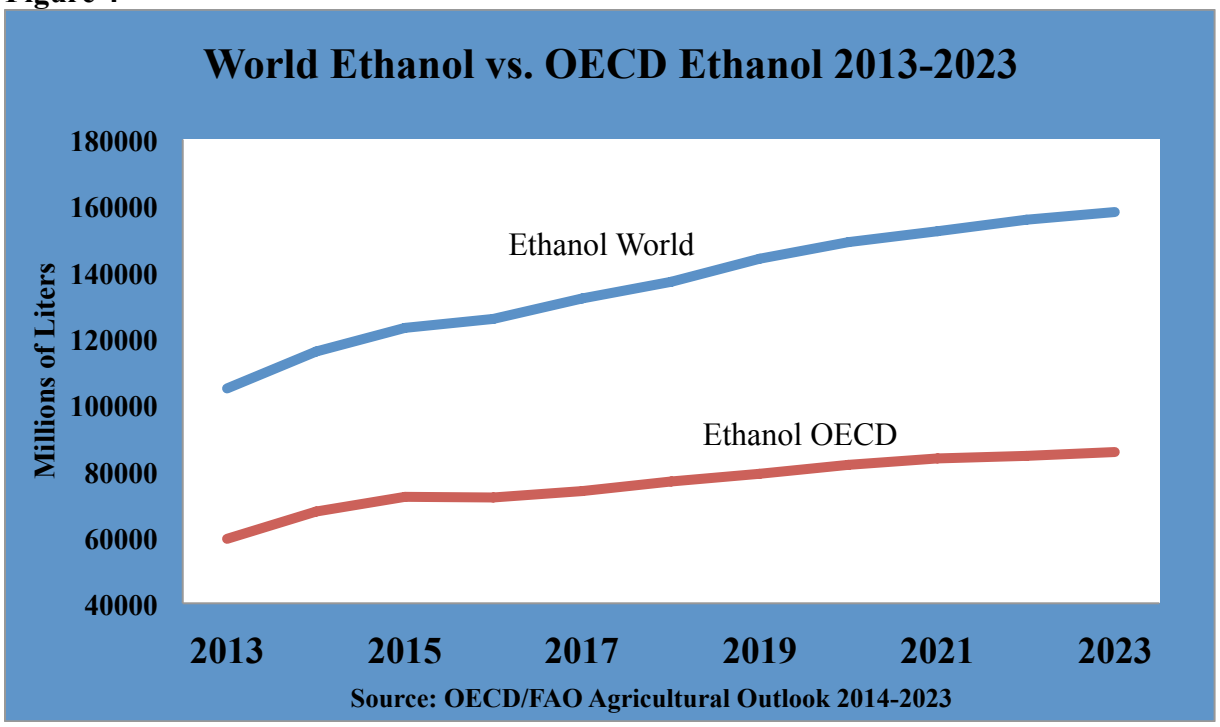
In addition, OECD/FAO predicts, "By 2023, 12%, 28% and 14% of world coarse grains, sugar cane, and vegetable oil production, respectively, are expected to be used to produce biofuels."[87]

While OECD countries dominate biofuels consumption today, the OECD/FAO report finds member states will play a less dominant role in the world biofuels market, as illustrated in the graph below. Brazil currently accounts for most consumption in Latin America, but it is Asia where OECD/FAO predicts biofuels will see the greatest growth, particularly in China and India.[88] Overall, OECD/FAO predicts that growth in ethanol production among developing countries from 45BL in 2013 to 71BL in 2023, will be mostly be driven by Brazil and its 25% ethanol mandate.[89]

OECD/FAO predicts U.S. ethanol use will be significantly restricted by the blend wall and will grow only marginally in terms of percentage consumption.[90] They assume only 12% of the U.S. cellulosic mandate will be implemented by 2023.[91] In addition, OECD/FAO considered political factors in its estimates, including the assumption that the biodiesel blender tax credit will not be renewed.[92] This political analysis is important in bringing predictions in line with political changes instead of assuming a continuation of current policy, although the biodiesel tax credit has typically been renewed.[93]

OECD/FAO's analysis of European demand assumes that current mandates will be fulfilled and carried forward at least through 2023. OECD/FAO finds further that the EU RED fulfillment percentage will be 8.5% accounting for allowable double-counting of GHG-reducing fuels (out of its mandate for 10% of transportation fuels coming from biofuels by 2020).[94]

Figure 4[95]



U.S. Energy Information Agency Projections

The U.S. Energy Information Administration (EIA) has arrived at very different projections from those of the OECD/FAO and IEA. EIA finds that world biofuels production will increase from 1.5 million barrels of oil equivalent per day (Mboe/d) in 2011 to 1.7Mboe/d in 2020, 2.7Mboe/d in 2035 and 3Mboe/d in 2040.[96] Similar to the other models, EIA sees OECD countries dominating production in the short term and non-OECD countries overtaking OECD output in the long term. The timeline for this change is much slower than the other models, however. In 2011 EIA has OECD countries producing 1.0Mboe/d and non-OECD countries producing only 0.5Mboe/d.[97] In this model, OECD and non-OECD countries do not produce equivalent amounts of biofuel (1.2Mboe/d) until 2030, and by 2040 non-OECD countries only lead OECD countries by 1.6Mboe/d to 1.3Mboe/d.[98]

Unlike the other two models, EIA does not see rapid growth in either China or India. While it predicts an annual percent change of 7.8% in India—a significant year over year increase—they find that India will not even produce 0.1Mboe/d by 2040.[99] EIA finds China will produce only 0.1Mboe/d by 2020, 0.3Mboe/d in 2035 and 0.4Mboe/d in 2040, but this growth still translates to a 300% growth rate from 2020 to 2040.[100]

IV. Country Mandates and Main Findings

Sixty-four countries now have biofuels mandates or targets.[101] The level of implementation varies dramatically among these countries, from fully implemented to just announced. Some countries have only begun to create a legal framework for biofuels blending (Mozambique),

while others have been producing and consuming biofuels for decades (Brazil). While the background information underlying our analysis is static, our findings show a great deal of movement within biofuels targets and mandates with many countries recently readjusting their mandates or targets both up and down based on price and availability of ethanol and biodiesel in their markets as well as in response to other political, social, and economic objectives.

Mandates and targets range from a high of 25% ethanol blend in Brazil and Paraguay to a low of a 1% biodiesel mandate in Taiwan. The EU's RED has a 10% blending mandate by 2020, but if reforms are approved only 7% is expected to be derived from food-based feedstocks due to recent proposals in the EU to cap the use of crop-based biofuels. The United States has a volume-based mandate that is effectively 10% currently because only up to 10% ethanol can currently be blended into the existing vehicle fleet; the U.S. Environmental Protection Agency (EPA) has approved a 15% ethanol blend (E15) for newer vehicles, but consumers are unlikely to use E15 soon due to due to its incompatibility with older vehicles and small engines, in addition to engine warranty and liability concerns.

In Latin America and East Asia, mandates are much more likely to be tied to levels of production, while mandates in Sub-Saharan Africa and South Asia are largely aspirational. For example, India recently scaled back its 20% ethanol target to 5% and is likely to be at just 2.5% in 2015. India initially hoped to support local sugar production, but faced several hurdles in implementing its plan. An outlier is Zimbabwe, which has invested heavily in biofuels and has a 15% ethanol mandate because it faces economic and trade sanctions, leading to ethanol being more economical than regular gasoline.

With the notable exception of Brazil, countries such as the United States and members of the EU were some of the first countries to implement biofuels mandates. Today, many countries in the developing world, especially biofuels producers, also have biofuels mandates. Our research finds that countries in the developed world are much more likely to have implemented their biofuels mandates or have come close to meeting biofuels targets/mandates (United States, Canada, and Germany) than countries in the developing world (India, Nigeria, and Ethiopia). This reflects both the time countries have had to meet these mandates and secure supply, but also the difficulties of starting a biofuels blending program.

This developed-developing world divide masks, however, the important differences between countries with established and functioning biofuels production and those without. Even in the developing world—especially emerging-market countries—countries where biofuels production has already taken root are consistently meeting their current mandates (Colombia and Ecuador). For countries without the buying power of the OECD, the driving factor behind the implementation of their mandates is the success or failure of domestic production (Panama and Zimbabwe).

In many cases mandates attempt to track biofuels availability and domestic consumption. Indonesia's palm oil biofuels industry is the best example of this trend. It currently has a 5% biofuels mandate, with a target of 15% ethanol and 20% biodiesel by 2025, not only to support domestic production, but also to absorb local demand in part due to the EU proposing to cap food-based biofuels at 7% of volume.[102] In Colombia, the ethanol mandate is explicitly reliant on

ethanol stocks and is either 8% or 10% depending on availability. This would also be true from a different angle in the United States if the EPA elected to waive the RFS mandate downward to reflect lower production of cellulosic ethanol.

Overall, there is great variety in mandates, with producers with excess capacity looking to expand their mandates and export biofuels, and importing and OECD countries leveling off their mandates either in terms of volumes or as a percentage of their total consumption due to various food-price, land-use, or environmental concerns.

Methodology

In the summary table below and in the more expansive tables in the appendices, we strive to present the most up-to-date information on whether biofuels volume mandates have been met and the primary feedstock being produced and/or consumed in these countries. As discussed later, there is very good data on biofuels production and consumption in OECD countries, but data are less complete in parts of the developing world and in countries that have recently adopted mandates.

Information has been compiled from industry, international and country reports, and U.S. Department of Agriculture (USDA) country reports. We have privileged the most up-to-date information in our search, but some of this information is a few years old. We have included information we were able to access through regular desk research methods. All of the information below and in the appendices is publically available.

The full list of countries and regions with biofuels mandates can be found in Appendix B. For purposes of analysis we divided the countries in the appendix into several categories, each of which has large consumers in the summary table:

- **OECD**, or developed countries such as the United States and EU, which mostly have 10% ethanol mandates and which mostly are moving toward those goals.

- **High-production countries meeting high mandates**, most notably Brazil and Argentina but also several other countries, such as Colombia and the Philippines.

- **High-production countries failing to meet high mandates or targets,** such as China, India, and Indonesia but also several other Asian countries such as Malaysia, Thailand, and Vietnam.

- Other **countries with aspirational mandates** or targets, with varying degrees of likelihood that they will meet them, such as Chile, Nigeria, and South Africa.

The majority of countries in the world do not have biofuel mandates or targets, and these include several large consumers. Most notable are large petroleum-producing countries such as Russia, Venezuela and the Persian and Arabian Gulf countries, although some of them import biofuels from countries such as Brazil and the United States. The United Arab Emirates is one of the

largest importers of U.S. ethanol, for instance.[103] They see little need or value in developing domestic biofuel industries.

As the summary table of selected biofuels consumption mandates shows (Table 1), full implementation of existing mandates and targets would represent a 43% expansion of first-generation biofuels demand over current levels. We present the seven most important biofuels consumers, their mandates and/or targets, their current consumption levels as both volume and as a share of transportation fuel, the additional volume and share implied by full implementation, and the total volume adding in anticipated demand growth for transportation fuels. Added transportation demand contributes significantly (20% of the overall increase in demand) to the total projected biofuels volumes in the countries in which the mandates/targets are a percentage of fuel, but the United States is the notable exception here. (A version of the summary table, with additional notes on sources, can be found in Appendix A.)

Growth pathways could increase further if full mandates/targets are fulfilled, not just those for first-generation biofuels. For instance, we assume: (1) India fails to meet its 20% biodiesel target, which is unlikely in the short-run; and (2) the United States meets mandates for first-generation biofuels but not for cellulosic biofuels, meaning just over half of the mandate is included in this analysis. We assume the United States uses 76BL of first-generation biofuels (such as corn ethanol, soy biodiesel, and sugarcane ethanol) in its fuel supply by 2025, out of a total of 137BL required by the RFS in 2022.[†]

Other assumptions in the summary table analysis include the following:

- EU estimate includes double-counting for advanced fuels, so the effective demand increase from its 10% mandate is 8.6%.[104]
- Consumption numbers for Brazil are calculated based on its 25% ethanol mandate, the latest figures available.
- Argentina's transportation demand is calculated differently because USDA estimates a change in ratio of gasoline to diesel. Separate demand increases were calculated for gasoline and diesel, which have implications for ethanol and biodiesel use.
- China has both a 10% mandate and a 15% target, but only for nine provinces. We assumed China would meet its 15% target because past targets have systematically been met. China's transportation fuel demand growth rate in affected provinces is assumed to be the same as China's overall growth rate. Where uncertainty in current implementation of mandates exists, the midpoint of the range was used for calculations (e.g. China 8-12% current ethanol blend was calculated at 10%).

[†] We assume the U.S. meets its 57BL mandate for corn starch ethanol, 3.8BL mandate for biodiesel (which could be increased by the U.S. EPA), and that the remaining 15BL are met by imported sugarcane ethanol (total of 76BL). We assume the remaining 61BL, mandated to be filled with cellulosic ethanol, a second-generation biofuel, are not produced due to technological and economic challenges, and that EPA waives down this mandate, leaving just 76BL of the mandate to be fulfilled. However, this volume could increase further if the U.S. Congress or EPA alters biofuels mandates to allow more food-based biofuels (such as corn biobutanol and corn oil biodiesel) to count toward its "advanced biofuels" mandate since cellulosic ethanol production has failed to materialize as policymakers projected in 2007.

- We only considered India's 5% ethanol mandate to be binding, so we did not assume the country's 20% ethanol and 20% biodiesel targets would be filled.
- Indonesia currently has a 5% mandate for biofuels, but also has more aggressive targets of 15% ethanol and 20% biodiesel by 2025. The higher targets are used in this analysis.
- All transportation growth is annualized on a linear basis from IEA and USDA growth rates.

Table 1: Selected Biofuel-Consuming Country Mandates through 2025
(in billions of liters)

Country	Mandate/target			Current Consumption		Mandated Increase	Transport Fuel Demand Growth through 2025	Added Volume, Full Mandate+ Demand Growth	Projected Demand 2025	
	Timeframe	Ethanol	Diesel	vol	% fuel supply	%	%	vol	vol	% increase
United States	2022	72 BL	3.8 BL	62.9		21%	N/A	13.1	**76.0**	**21%**
European Union	2020	10.0%		18.7	5.0%	72%	-8%	12.1	**30.8**	**64%**
Brazil	2014	25.0%	7%	29.0	27.5%	0%	36%	12.2	**41.2**	**36%**
Argentina	2014	5%	10%	2.0	7.6%	25%	57%	1.3	**3.2**	**64%**
China*	2020	15%	-	3.6	8-12%	50%	59%	3.9	**7.5**	**109%**
India	2014	5%	-	2.3	2.1%	42%	47%	2.0	**4.3**	**89%**
Indonesia	2025	15%	20%	0.8	3.0%	795%	65%	7.1	**8.0**	**860%**
Total Selected				**119.2**				**51.6**	**170.9**	**43%**

Sources:
All current volumes are taken from the most recent US Department of Agriculture (USDA) GAIN reports unless otherwise noted.
Transport fuel demand growth rates are calculated from IEA's New Policies Scenario except for Indonesia and Argentina.
Ethanol and diesel demand estimates for Argentina, for 2015-2024, are taken from USDA's GAIN Report for Argentina, 2014.
Ethanol and diesel demand estimates for Indonesia, for 2015-2024, are taken from USDA's GAIN Report for Indonesia, 2014.
Diesel consumption for India is derived from USDA's GAIN Report for India, 2013.
Current volumes for the US are the Environmental Protection Agency's (EPA) 2013 mandated biofuels volumes.
*China's mandate is for nine provinces only, representing just 1.1% of current fuel use and a projected 1.3% in 2025.

Full Implementation of Existing Mandates

As the table shows, most large consuming countries with mandates or targets have only partially implemented them, Brazil being the most notable exception. The United States is close to fulfilling its mandate for first-generation ethanol (13BL away from its 76BL mandate of first-generation biofuels). The EU is about 12BL away from its overall 10% mandate, though there is wide variation among member countries in their progress.

OECD countries drive current consumption and account for about half of the growth in projected biofuels demand by 2025. This would be considerably lower if the United States and the EU reformed their mandates. As noted earlier, the EU is currently considering capping the use of crop-based biofuels at 7%. (Here we estimate implementation based on the full 10% mandate, adjusting for double-counting.)

Mandates and targets in key large emerging economies have important implications for future growth in biofuel consumption and production. Information is less reliable, and policy goals are under revision. Still, we present the likely mandates/targets of major biofuel-producing countries and their implications.

Brazil is a large producer and consumer, with high mandates that have been filled. The projected 36% increase in its consumption comes solely from fast-growing demand for transportation fuels, a high percentage of which are biofuels. While the pie may be getting bigger, biofuels' share of the transportation fuel supply is expected to stay relatively flat. Argentina is a much smaller consumer with lower mandates, but increased transportation demand, in addition to increased mandates, are expected to lead to a 64% increase in consumption by 2025.

Two of the least certain mandates include those in China and India. China currently has a 10% mandate in nine provinces only, which it has reached, with a target of 15%, suggesting 50% growth in demand from the target alone. Given anticipated high growth rates in demand for transportation fuels in addition to increased biofuels targets, the projected growth rate is 109% through 2025. This represents an increase of only 3.9BL despite the high percentage increase because the mandate is limited to nine provinces. Future Chinese biofuels policies are expected to continue to be mindful of food vs. fuel concerns (which began after food price spikes in 2008) and future analyses of demand for agricultural commodities. Nationally, biofuels now account for just 1.1% of transportation fuels and that share would grow to just 1.3% in 2025.

India is only halfway to meeting its 5% ethanol mandate, recently scaled back from 20%. Its 20% biodiesel target has not been reduced, but we do not include it here as it is not a binding mandate and, as we explain below, there is good reason to believe India will have to reduce it. Still, even without added biodiesel, we expect India's biofuel production to increase 89% to 4.3BL by 2025.

Indonesia presents the largest planned growth on a percentage basis (860%) as it moves from its current 5% biofuel mandates to aggressive 15% and 20% targets for ethanol and biodiesel, respectively. With high anticipated transportation fuel demand growth, such targets would make Indonesia one of the most significant sources of new demand for biofuels between now and 2025 – 8.0BL – with the bulk of the feedstock expected to come from palm oil.

Overall, these countries account for the large majority of current biofuel production. Assuming they continue to account for such a proportion, the impact of full implementation of their mandates and targets would have huge impacts on land use, water quality and quantity, food prices, and GHG emissions. Our figures suggest a 43% increase in first-generation biofuels consumption over current levels. This world in which 3-5% of the global fuel supply is comprised of first-generation biofuels is close to projections offered by the OECD/FAO scenario. However, growth rates could increase to 115% if second-generation biofuels mandates are met and if other countries such as India meet their lofty biofuels targets. This would result in a world in which 4-7% of the world fuel supply is comprised of biofuels, which is closer to IEA estimates.

For a full list of country mandates please see Appendix B.

Limits to Full Implementation

There is good reason to believe that many countries will be unable to fulfill their current mandates. For some, such as countries in the EU, a likely future 7% cap on food-based biofuels (out of a 10% mandate) leaves a 3% gap to be filled with non-food-based biofuels that have been slow to come to full commercialization. Many countries have yet to meet even the proposed 7% cap. For the United States, the blend wall currently prevents the full implementation of the RFS, and since cellulosic biofuels are required to meet nearly half of the 137BL mandate, policy reforms will be required to bring the mandate more in line with realistic production volumes. For others, such as India, access to feedstock (sugar) is proving difficult to secure.

There are, of course, risks that additional mandates in key countries could add to biofuel demand in ways not anticipated here. As is often the case, China and India are the two most important wild cards for such estimates.

Below we analyze the likelihood of implementation, recent calls for reform, and present the key factors guiding the development of biofuels policies, consumption, and production in selected countries and regions. We find that if recently-proposed policy reforms are implemented (such as in the United States and EU), we can expect lower first-generation biofuel growth, but overall global demand is still expected to increase significantly.

United States

The United States is the world's largest biofuels producer and consumer.[105] The twin pillars of U.S. biofuels policy have included a mandate as well as an intertwined set of subsidies focused at the dominant feedstock (corn), as well as refining and blending facilities (some of which have expired). While the largest tax credit for ethanol production, the Volumetric Ethanol Excise Tax Credit (VEETC), ended in 2011, the biodiesel blenders and cellulosic ethanol production tax credits are routinely extended. State incentives and other federal government programs have also contributed to establishing the required infrastructure to make biofuels production economically viable.

The RFS mandates 137BL of conventional ethanol (mainly corn ethanol), advanced biofuels, and cellulosic biofuels to be blended into the U.S. fuel supply by 2022. In the U.S. mandate, definitions of these different types of biofuels are based primarily on their contributions to reducing life-cycle GHG emissions, as estimated by EPA. In our analysis, we assume the corn ethanol, biodiesel (biomass-based diesel), and a portion of the advanced biofuels mandates will be met (totaling 80BL of the full 137BL mandate), but importantly, we do not assume the 61BL cellulosic ethanol mandate is met since production is just beginning to come on line and experts estimate the mandate will not be filled by 2022. The gap that exists between the advanced biofuels and cellulosic ethanol mandates creates an incentive for additional production/importation of food-based biofuels such as imports of sugarcane ethanol from Brazil and production of other food-based biofuels such as soy biodiesel and corn biobutanol.

U.S. Renewable Fuel Standard Definitions

The RFS mandates increasing levels of the following types of biofuels by 2022:

- **Corn starch ethanol:** the mandate for corn starch ethanol is 57BL by 2015, and this mandated level continues throughout the life of the full RFS. This category is required to meet a 20% GHG reduction threshold (as compared to U.S. gasoline), although several corn ethanol facilities were grandfathered into the law, meaning they were not required to reduce GHG emissions.

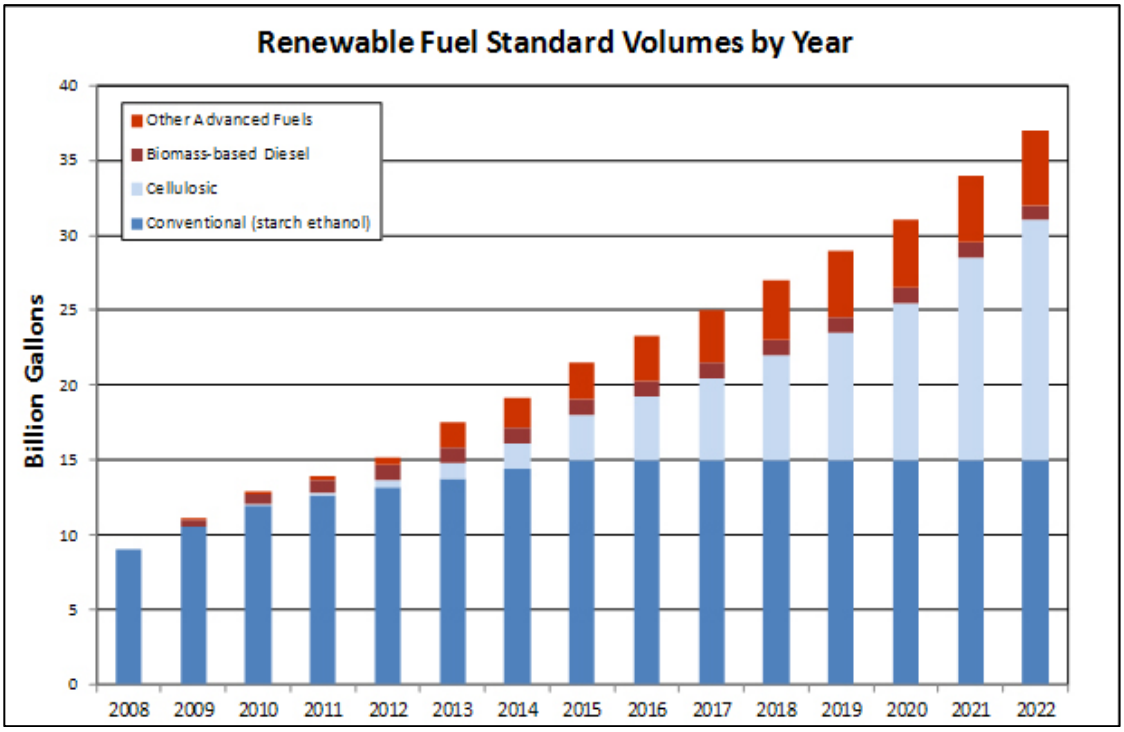
- **Advanced biofuels:** Rising to 80BL by 2022, the advanced biofuel mandate may include biofuels such as sugarcane ethanol, biomass-based diesel (such as biodiesel derived from animal fats, soy, or other vegetable oils), cellulosic ethanol (see below), and other advanced biofuels. These are required to meet a 50% GHG reduction threshold set by the U.S. EPA. The EPA is currently considering whether to treat corn biobutanol, a fuel that does not face the same fueling infrastructure challenges as corn ethanol, as an advanced biofuel, meaning that food-based biofuels may still be considered advanced biofuels in the United States

- **Cellulosic ethanol:** Rising to 61BL by 2022, the cellulosic ethanol mandate may include ethanol derived from cellulosic sources such as perennial grasses and wood and agricultural residues. This category is required to meet a 60% GHG reduction threshold. However, cellulosic ethanol is not produced at a large commercial scale yet, so in our analysis, we do not assume the United States meets its 61BL cellulosic mandate by 2022 (or 2025), leaving a gap of 19BL of advanced biofuels to be filled with fuels such as sugarcane ethanol and soy biodiesel (identified as "other advanced biofuels" in Figure 8).

Figure 5 details the scheduled increase in RFS mandated biofuels volumes, with corn ethanol leveling off at 57BL in 2015 and years thereafter, and cellulosic biofuels mandated to grow steadily after 2010.

Approximately 10% of U.S. gasoline supply currently comes from ethanol—primarily corn ethanol, while biodiesel blends are much lower. Growth projections are relatively flat though, given the issue of the E10 blend wall. The most recent EIA estimates project that biofuels will account for only 11% of U.S. transportation fuel in 2040, although its previous energy projections have estimated significantly higher volumes of biofuels.[106] As a comparison, the RFS mandate requires approximately 25% of the United States fuel supply be comprised of biofuels by 2022, the majority from cellulosic or advanced feedstocks.

Figure 5 [107]



Three key issues have led to the U.S. biofuels market expanding at a significantly slower rate than initially thought. First, Americans are driving less. The Great Recession led to large reductions in driving and this behavior change has not rebounded at the same rate as the economy. The EIA also projects that there will be fewer drivers per capita in the future.[108]

Second, Americans are driving more fuel-efficient cars. Higher Corporate Average Fuel Economy (CAFE) standards are lowering fuel demand. So are American preferences for cars with better fuel economy. Trading large vehicles for smaller cars and hybrids is leading to demand far lower than the EIA anticipated 10 years ago.

Third, the United States has hit the blend wall, or the maximum amount of ethanol deemed safe to blend into the U.S. fuel supply. Gasoline blended with 15% ethanol (E15) is now allowed in cars manufactured after 2001, but it is not available in most areas and issues with engine warranties and negative effects on older vehicles and small engines have prevented its widespread adoption. In addition, for the reasons cited earlier, unlike Brazil there is little indication the United States will significantly increase adoption of flex-fuel vehicles in the near future. If either of those occurred, the U.S. fuel supply could accommodate significantly higher levels of biofuels.

Each year, the Environmental Protection Agency (EPA) is able to revise RFS mandates based on the commercial availability of cellulosic biofuels. In recent years, the EPA has reduced cellulosic ethanol mandates by more than 95% because each year less cellulosic fuel is available than the RFS originally mandated. In 2015, EPA will consider waiving the *entire* RFS downward for

calendar year 2014, for the first time in history, due to these lower cellulosic volumes and the ethanol blend wall.[109]

Such reforms can make a large difference in global biofuel demand. If EPA finalized 2014 biofuel volumes in line with those proposed in late 2013 (one way to reform the RFS) and maintained these lower mandates throughout the rest of the RFS, the United States would contribute 4.6BL less to global first-generation biofuel demand, leading to a 14% demand increase instead of a 21% increase by 2022.

EPA is also able to waive RFS mandates downward based on petitions tying biofuels mandates to "severe economic harm." While several petitions have been submitted to EPA in recent years by U.S. states negatively affected by high crop and food prices, EPA rejected these citing other demand factors playing a larger role in higher food prices. In addition to administrative action, several legislative proposals have been introduced in the U.S. Congress to either eliminate or significantly reform biofuels mandates due to their impacts on food and feed prices and negative effects on the environment. If implemented, reform proposals would bring biofuels mandates more in line with current production volumes.

The arrival of the blend wall and the failure of cellulosic ethanol to come to large commercial production have resulted in numerous unintended consequences of the RFS. Combined with low feedstock (corn) prices, ethanol production in the United States is beginning to exceed the amount of ethanol that can be used in the current domestic vehicle fleet. Hence, U.S. ethanol exports are expected to increase to record levels in 2015 due to this confluence of factors. The RFS has also created a particular market for Brazilian sugarcane ethanol in the United States since cellulosic ethanol has failed to meet advanced biofuels mandates. Hence, in addition to soy biodiesel, sugarcane ethanol from Brazil is a major source of advanced biofuels, with imports of 7.7BL in 2013.[110] OECD projects that by 2023 Brazil could supply up to 38BL to the United States while the United States ships 19BL of corn-based ethanol to Brazil.[111] Others consider this level of bilateral ethanol trade unlikely.

Because Brazil has no restrictions in its own mandates or laws on GHG impacts, corn ethanol can substitute freely in the Brazilian market for some of the sugarcane ethanol exported to the United States The net effect leads to expansion of less beneficial corn-based ethanol fuel beyond its RFS mandate, while the mandate for advanced biofuels is met with additional food-based biofuel. However, these trade flows are highly dependent on volumes that the U.S. EPA finalizes, since the agency can lower advanced and cellulosic biofuels mandates if production is insufficient. Furthermore, the advanced biofuels gap at most is 19BL, with some of this likely being filled with soy biodiesel, so these projections are highly speculative.

The RFS provides a prime example of how domestic mandates interact with existing trade flows and lead to unexpected outcomes, and ones that frequently undermine the political purposes for which a domestic biofuel mandate was originally passed. And since the RFS has primarily been filled with corn ethanol, the RFS has failed to significantly reduce GHG emissions.[112]

European Union

In 2009, the European Commission (EC) established a minimum target of deriving 10% of transportation fuels from biofuels in each member state by 2020. Countries submitted their energy action plans to the Commission by June 2010.[113] During that time, civil society became concerned about both the environmental and social ramifications of this decision. As more evidence became available about indirect land use change due to biofuels, biofuels' effect on food prices, and the human and land rights issues associated with the production of biofuels in some countries around the world, advocates mobilized to change the law. In part, advocates were able to point to the sustainability criteria laid out in Articles 17, 18, and 19 of Directive 2009/28/EC.[114] These GHG and land use sustainability criteria have been in effect since December 2010.

As a result of these intense educational efforts, in October 2012, the EC proposed limiting food-based biofuels to 7% of the 10% renewable energy target in the RED.[115] While it does not go far enough, three-percentage points less in first-generation biofuel represents 11BL in avoided production (assuming the remaining 3% would be difficult to meet with non-food-based feedstocks). This reform would reduce the EU's projected growth rate in first-generation biofuel volume from 64% to 33%, (which also factors in a drop in transportation demand growth through 2025). Because this reform has not yet been implemented, the higher 10% biofuels mandate has been used in our analysis.

OECD/FAO reports 65% of European vegetable oil is being used for biodiesel.[116] In addition, several companies based in EU countries have acquired land in African countries to produce biofuel feedstocks, some of these resulting in land grabs which deprive local communities of land once used for food production, housing, burial grounds, forestry, etc.

The following table shows the origin of biofuels consumed in the EU.

Figure 6[117]

Origin of final biofuels consumed in the EU in 2010[17]

	Biodiesel		Bioethanol		
	Volume (ktoe)	Share		Volume (ktoe)	Share
EU	8,270	83.2%	EU	2,243	80.1%
Argentina	1,003	10.1%	Brazil	234	8.4%
Indonesia	285	2.9%	U.S.	121	4.3%
Malaysia	123	1.2%	Peru	26	0.9%
China	67	0.7%	Kazakhstan	24	0.8%
U.S.	61	0.6%	Bolivia	20	0.7%
Other countries	129	1.3%	Egypt	15	0.5%
			S.Korea	16	0.6%
			Other countries	101	3.6%
Total	9938			2800	

Source: EUROSTAT, COMTRADE.

Figure 7 shows the origin of the feedstocks of biofuels consumed in the EU, showing the EU's dependence on imports of feedstocks.

Figure 7[118]

Origin of all biofuel feedstock consumed in the EU in 2010

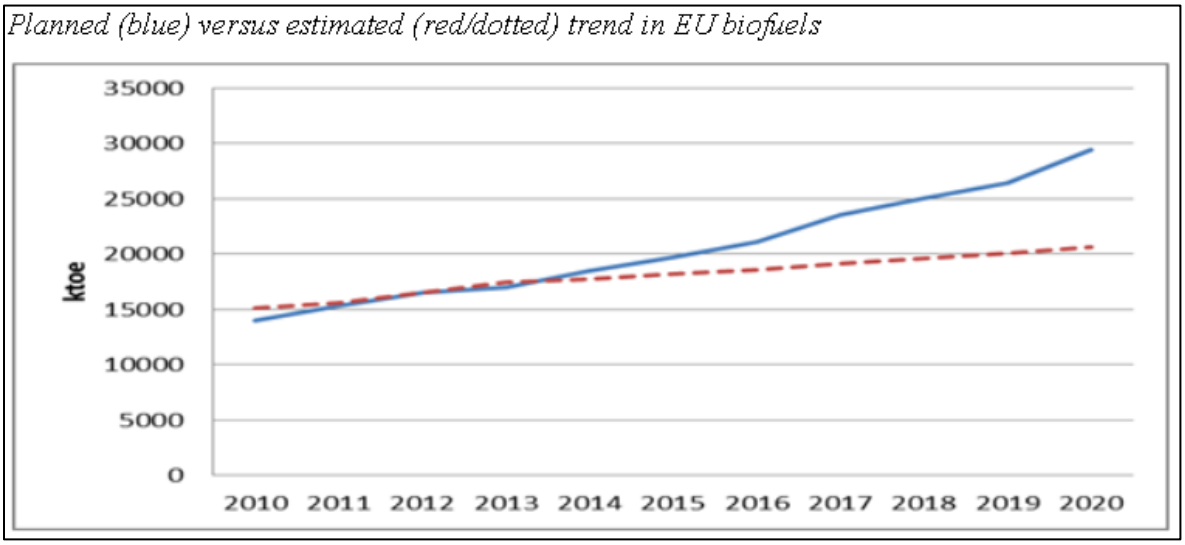
EU	Argentina	Indonesia	Brazil	U.S.	Canada	Ukraine	Malaysia	Paraguay	Other
63.9%	9.7%	6.6%	5.3%	3.0%	2.4%	2.3%	1.7%	1.5%	1.3%

Russia	China	Switzerland	Peru	Bolivia	Peru	Egypt	Guatemala
1.0%	0.5%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%

Overall, progress toward the 10% mandate has been uneven, leaving the EU as a whole unlikely to reach that goal, although added consumption is still projected to be an important driver of global biofuels demand. According to the EC, biofuel use in 2020, the end of the mandate period, is expected to be just two-thirds of the planned total.[119] (See Figure 8.)

Some European countries are already well on their way to meeting the 10% target, with Sweden already blending 10% biofuel into its transportation fuel. However, other countries such as the UK and Spain have yet to meet the newly proposed 7% cap on food-based biofuels, meaning there is still room to expand current blending levels. And since production of non-food-based biofuels has been slow due to technological and economic challenges, meeting the overall 10% targets will be difficult. Despite these constraints, recently proposed reforms, and concerns about biofuels' environmental and social impacts, the EU biofuel market is expected to continue to grow.

Figure 8[120]



Brazil

A dominant force in biofuels markets, Brazil has the longest running biofuels mandates in the world, a large flex-fuel vehicle fleet (which can operate on Brazil's 25% ethanol blend mandate) as well as tax incentives for biofuels production. Brazil's production and consumption of biofuels continue to increase. Ethanol production in 2015 is projected to be up 5% over 2014 at 26.9BL.[121] The Brazilian Senate passed a measure to increase the ethanol mandate to 27.5% from 25% and to cap biodiesel blending at 6%, but the proposal has yet to be approved by the

President.[122] In any case, the mandates in Brazil are seen more as a reflection of the market than a driver, in part because it affects only a small share of ethanol used in the country's vehicle fleet.

In addition to its domestic consumption, Brazil was also the world's largest ethanol exporter in 2013, although exports were down significantly in 2014.[123] In this interconnected market, Brazil exports sugarcane ethanol to the United States while the United States sometimes exports corn ethanol to Brazil to make up for losses. The United States is also its largest importer and accounts for 70% of Brazil's exports of ethanol.[124] Brazil's exports are projected to drop 46% in 2014 to 1.5BL as the United States considers scaling back its mandates for advanced biofuels, although previous estimates from the OECD/FAO projected increased ethanol trade over the next ten years.[125]

Even outside of the U.S.-Brazil relationship, Brazil has been a significant supply-side driver of the global biofuels market. It has used its technical expertise in ethanol as a source of soft power toward other emerging and developing countries to increase biofuels use, although this has leveled off in recent years.[126] For example, Brazil has invested in land, entered into "cooperative agreements," and provided biofuels technology to other countries, including many in Africa and countries in the Western Hemisphere.[127] Brazil and the U.S. signed a Memorandum of Understanding (MOU) in 2007 aimed at increasing agricultural and biofuels investments in developing countries such as Honduras, Nicaragua, Costa Rica, Panama, the Dominican Republic and Haiti, which the governments termed "ethanol diplomacy" at the time.[128] As a Committee on Foreign Relations (CFR) brief wrote in 2007, "Ethanol ha[d] become Lula's [Luiz Inacio Lula da Silva, the former President of Brazil] best diplomatic lever in Latin America…"[129]

Despite its influence, the domestic Brazilian ethanol industry has recently seen setbacks, including a reduction of gasoline taxes resulting in relatively cheaper gasoline and the country's discovery of new oil deposits, which may decrease domestic oil prices – the opposite reason biofuels mandates were first enacted in Brazil.

Argentina

Behind only Brazil in biofuels production and consumption in Latin America, Argentina has invested heavily in both ethanol and biodiesel production. A 10% biodiesel mandate and an ethanol blend rate of 7.6%--even higher than its 5% mandate—are driving Argentina's consumption of biofuels.

Argentina's biofuels production and consumption have expanded rapidly over the last few years. In 2010, Argentina's ethanol blend rate was only 2% but it is expected to rise to 7.5% in 2014.[130] As ethanol demand rises, Argentina is adding additional refining capacity, creating the infrastructure for future production. In the past year a new ethanol plant has brought annual production capacity up to 840 million liters.[131]

Its biodiesel blend rate is expected to double to 8% in 2014, from 4% in 2010. [132] In 2014, its biodiesel consumption and production were projected to be 1.4BL and 2.6BL, respectively, leaving room for biodiesel exports.[133] [134]

Peoples Republic of China

China initially embarked on a biofuels policy to absorb excess grain stores in the early 2000s. It switched course when the 2008 food price spikes led to concerns about shortages if this food was converted to fuel. Since then, China has invested in so-called advanced biofuels that can be grown on marginal land.[135] It has also involved its national oil companies in some biofuels production, showing its interest in developing biofuels for national energy security.[136]

When China makes investments, an entire market can move. The second largest economy in the world and home to one-sixth of the world's people, China has included biofuels in its current five-year energy plan. The U.S. EIA reports China produced 2.6BL of ethanol and 966 million liters of biodiesel in 2013.[137] Compared to the production of the United States or Brazil, these volumes are small. China has mandated 10% ethanol blends in gasoline in nine of its provinces, but this mandate is set to increase to a 15% target in 2020.[138] China is such a large market that these mandates and other infrastructure investments are worth particular attention.

China's investments in biofuels reflect their general approach to energy investing, ensuring the country is investing in all industries and that they are prepared for technological gain in any particular one. If, for example, cellulosic biofuel were to become commercially viable, it is likely China would be an early investor and adopter of this fuel. China is a large net importer of transportation fuel and depends on fuel for its continued economic growth. Considering China's investments in overseas oil fields, its investment in biofuels is modest indeed.

The quick reversal of policy in 2008 demonstrates that China is not wedded to biofuels production for ideological reasons and is likely to be sensitive to biofuels' competition with food crops to the extent that it affects food prices. Without powerful interest groups promoting biofuels, it is better able to adjust quickly to changes in the market either expanding or contracting its production. China has also recently announced it will remove or dial back other policy supports for ethanol. In 2015, it will remove the 17% value-added tax rebate at the same time it is adding a 5% tax on food-based biofuels.[139]

Based on China's stated intentions and recent actions on biofuels, it seems unlikely the government will increase its 15% biofuels target in the near future. Nor is it likely to extend the target to other parts of the country. As demand rises, of course, its consumption of biofuels will rise even with the same target in place. But its limited mandate means that presently only 1.1% of China's transportation fuel comes from biofuels, and even with anticipated growth that percentage would rise to just 1.3%.

If China were to choose to increase dramatically its biofuels production or consumption, it could dwarf production and consumption of many OECD countries. Any move to take the nine-province mandates national would have dramatic impacts, as would policies to import large quantities of biofuels. The environmental and human impacts could be overwhelming. In all models of future biofuels production and consumption, China, and to a lesser extent India, are wild cards, although China has a history of being an innovator in biogas and other homegrown bioenergy sectors.

India

The world's largest democracy embarked on a national biofuels policy in 2009.[140] Like China, India is a major transportation fuel importer and is hoping to improve its trade balance, support local agriculture and agricultural processing, and insulate itself from international oil markets by making non-petroleum energy investments. With a declared non-binding target of a 20% biofuel and biodiesel blend in transport fuels by 2017, India has publicly committed to scaling up biofuels production, but in practice it has done far less.[141]

In 2012, India's Cabinet Committee of Economic Affairs recommended its ethanol *target* be scaled back and changed to a 5% blending *mandate*. The country is currently blending only 2.1% ethanol into its transportation supply.[142] This is mainly due to limited supplies of sugarcane, especially after poor harvests in the past few years. Even with this dramatic reduction in its blending goals, India is projected to produce 2BL of ethanol in 2014.[143]

India's biodiesel target of 20% remains in place, but it is non-binding and it has not been replaced with a binding mandate (as was done with ethanol). The biodiesel industry has also failed to develop, with production in 2013 of just 115 million liters. The primary feedstock was intended to be jatropha, but the government and other countries are now searching for alternatives given its potential to become an invasive feedstock and its high water usage. Meeting the 20% biodiesel target would raise the country's biofuel use to more than 20BL, making it one of the world's largest biofuel consumers.

The Indian government set these initial targets in response to the country's impressive economic growth rate, fluctuating international oil prices, and a desire to be more energy secure.[144] In its own biofuels policy document it makes clear that its policy, unlike those of other countries, will not come into conflict with its food security goals and that biofuels will be derived from non-food feedstocks.[145] India is, however, unlikely to take food security concerns of other countries into consideration in its own biofuels import policies. Moreover, if a fully functioning, large-scale biofuels industry comes online, it is unclear if and how the Indian government would reverse its policy decisions to protect food security.

Despite significant targets and the outsized power of large sugar producers in India, it is unlikely that India will end up blending nearly as much ethanol and/or biodiesel by percentage into its transportation supply as Brazil. India's commitment to food security and its stated goal of prioritizing food security over biofuels development also makes it likely that its program will not grow significantly in the future. These qualifications aside, India's continued economic growth and increased energy demand coupled with its growing population could drive very high biofuels consumption even with its current blend rate. In terms of volume, India's demand could expand dramatically in the coming decade without changing its percentage mandate.

Indonesia

In 2011, Indonesia was the sixth largest producer of biodiesel.[146] Over the past several years, Indonesia has cleared huge tracks of land for its main biodiesel feedstock - palm oil – intended both for export and domestic consumption. Since the EU's adoption of a biofuels mandate,

Europe has become a significant consumer of Indonesian palm oil. A new proposal to limit biofuels from food-based feedstocks to 7% in the EU RED, in addition to broader concerns about unsustainable production of palm oil, has slowed exports to Europe.[147]

Indonesia is now using domestic mandates to drive local consumption as it continues to support production for both domestic and export markets through production subsidies and tax incentives.[148] It is too early to say if Indonesia's aggressive 2025 targets—15% for ethanol and 20% for biodiesel—will be met.[149] It currently has a 5% biofuel mandate, but is blending only 4.5% biodiesel and a marginal volume of ethanol.[150] Nevertheless, such dramatic growth in mandates and targets, especially as the country experiences economic growth and increased energy demand, would have huge environmental and social implications unless the government adopts smallholder-led palm oil development strategies and works to close the "productivity gap" with Malaysia.

Indonesia's biofuels expansion and other palm oil demand drivers have resulted in numerous negative impacts, including deforestation, large GHG emissions, and land and human rights issues. Groups such as the Rainforest Alliance, World Wildlife Fund, and Girl Scouts U.S.A. have raised issues of negative consequences of increased palm oil production in Indonesia such as "land-grabbing," forced displacement of communities, poor labor standards, large GHG emissions, and destruction of wildlife habitat. [151]

African Nations

Several African countries have enacted ethanol mandates or targets. Many of these mandates are new and were created in anticipation of domestic biofuels industries. It is too early to tell whether these mandates and targets will drive demand and help support these nascent industries.

South Africa, the most developed of the Sub-Saharan nations, has only begun its biofuels mandate, which is relatively low in any case – 2% ethanol and 5% biodiesel starting in 2015. Significant restrictions on water and land availability in the country make the development of a large domestic biofuels sector unlikely.[152] Moreover, South Africa has excluded maize use for biofuels because of food security concerns, and has also excluded jatropha for fears of it becoming invasive.[153] Despite these restrictions, there were four bioenergy projects operating in 2010 with four more in the pipeline,[154] and South Africa has begun to export ethanol to the EU.[155]

Countries from Senegal in West Africa to Tanzania in East Africa have been the sites of biofuels related land-grabs and failed biofuels projects as international companies seek new land to produce feedstocks in developing countries. Developed country biofuels mandates drive investment in not only biofuel feedstock production (such as sugar) but also biofuel refining facilities. Business setbacks as well as local unrest over forced displacement and other human rights abuses have been raised as reasons why governments should reconsider biofuels mandates, targets, and other incentives and investments in biofuels. Malawi and Zimbabwe are exceptions, being two of the only major producers of ethanol in Southern Africa. Zimbabwe, for instance, is currently blending 15% ethanol.[156]

It is unclear how African countries will approach biofuels moving forward. This is particularly true of countries and regions with recent discoveries of oil and gas. While countries like Angola and Nigeria have put biofuels mandates on the books, it seems unlikely that these large oil producers will follow through on these mandates. The lower domestic price of oil, especially with oil subsidies, makes biofuels particularly uncompetitive in these countries. Like oil producers in Northern Africa where no biofuels mandates exist, Sub-Saharan producers are unlikely sources of high biofuels consumption irrespective of the biofuels mandates they have on the books.

If OECD countries continue to demand biofuels, African production of biofuels is likely to expand in the coming years to meet at least part of this expanded demand. This is especially true in countries such as Ethiopia and Tanzania, which have prioritized large-scale commercial agriculture and foreign direct investment in the sector.

V. Conclusions

Our review of government biofuels mandates suggests consumption of first-generation biofuels in selected major biofuel-producing countries would increase about 43% by 2025 if most of these countries' mandates and targets were fully implemented. This analysis does not include mandates and targets that have little chance of implementation such as India's biodiesel target. The figure would be somewhat lower if existing mandates prove too difficult to achieve, and in some countries that is likely to be the case. First-generation biofuels consumption could be much higher by 2025 if the 64 current governments with mandates/targets continue expanding mandates/targets or if additional countries enact and actively pursue implementation of domestic biofuels mandates or targets.

Over the next ten years, OECD countries will continue to account for nearly two-thirds of first-generation biofuel consumption, and the fulfillment of their mandates would contribute to 50% of added first-generation biofuel use between now and 2025. The United States would be the largest contributor of new biofuels demand, adding 13BL, while the EU would add 12BL by 2025 to meet first-generation biofuel mandates. The United States would remain by far the largest consumer in 2025, with 76BL of first-generation biofuel consumption, which is projected to increase 21% in the coming years barring major policy reforms.

However, if recently proposed EU reforms (to cap food-based biofuels at 7% of the fuel supply) and U.S. EPA reforms (to limit the growth of biofuels expansion) were implemented, the EU and United States would contribute 11BL less to global first-generation biofuels demand in 2025; this would reduce mandate-driven global expansion from 43% to 38%. While these reforms do not go far enough, this demonstrates the impact that short-term policy reforms can have on global biofuels expansion.

Brazil will continue to be a major producer and consumer of biofuels, remaining the second largest consumer in 2025 after the United States with 41BL of consumption. Its consumption is projected to expand 36% if biofuel blending levels are maintained due to increasing demand for transportation fuel as a result of economic growth. The country is expected to continue to be a

net exporter, helping other countries fulfill their mandates. This has historically included the export of first-generation biofuel (sugarcane ethanol) to the United States for its advanced biofuel mandate in exchange for the import of another (corn ethanol). However, the economics of fuel blending could change if Brazil expands its oil industry, with the recent discovery of offshore oil, which is expected to increase its proven reserves and double its production capacity by 2020.[157]

China and India present the biggest sources of uncertainty. Any significant moves toward expanded biofuel consumption, over today's comparatively low levels, would have huge impacts for the environment, food prices, and agricultural markets. Based on current mandates and policies, however, the two are projected to contribute an additional 6BL to global consumption, barely half the consumption added by the United States. China's projected blend rate in 2025 is just 1.3%, moderation which keeps the country's large transportation sector from driving biofuel demand to even more unsustainable levels.

Indonesia, on the other hand, has the most aggressive targets, which it is moving to implement. Full implementation would add 7BL to global biofuel demand. This would only deepen the negative environmental and social impacts caused by the country's expanded production. In part, the EU biofuels mandate was responsible for Indonesia's large-scale planting of palm oil, in addition to other demand factors for palm oil and the government's intent to prop up domestic palm oil prices. The government's current mandates have responded to reduced demand by increasing domestic biofuel demand to absorb the excess feedstocks.

Given this increased demand for biofuels, the implications for land and water use and food security are huge. A 43% increase in biofuel production by 2025 would continue to divert food and feed crops into fuel markets. At current land-use rates, it would divert an additional 13-17 million hectares more land than we are currently already devoting to biofuel production and approximately 145 billion more liters of water at rates currently used in corn ethanol production. This is an important area for further research, with the implications depending significantly on the feedstocks used.

If the IEA's projections, which predict full implementation of global biofuels mandates, are accurate, however, our findings would represent only a portion of increased biofuels demand over the next two decades. Importantly, IEA includes second-generation biofuels mandates in addition to those for first-generation biofuels, suggesting that by 2035, the world fuel supply would be comprised of 8% biofuels by volume, with 80% of the biofuels still derived from food crop sources instead of second-generation, non-food feedstocks such as agricultural residues or perennial grasses. Meeting first-generation biofuels estimates would result in consistent growth rates to reach a world with 6% of transportation fuel comprised of biofuels by 2035, in line with our projections if full (first- and second-generation) mandates are met.

Policy Implications

This analysis suggests the need for governments to cease the implementation, expansion, and creation of new food-based biofuels consumption mandates. While recently proposed reforms to U.S. and EU mandates are welcome, even if they are implemented these OECD countries will

still account for about one-third of new biofuel demand over the next ten years. Percentage-based mandates, which prevail in most countries, will require additional demand for biofuels as demand for transportation fuels is expected to grow about 16% by 2025; many countries that maintain and enforce such mandates will contribute added demand for biofuels even if they don't increase their mandates.

Governments need to scale back their mandates further, enforce strict sustainability criteria, and ensure that so-called "advanced" biofuel mandates are not feeding further first-generation production or continued production of food-based and land-intensive biofuels.

Other policy recommendations that flow from this analysis include:

- *Remove Food-Based Mandates.* The United States should eliminate food-based biofuels mandates and ensure that future biofuels don't compete heavily with land used for food production.
- *Stop and Do Not Adopt New Food-Based Mandates.* Other countries should eliminate and forgo adoption of food-based and land-intensive biofuels mandates and other incentives working at cross-purposes with food security, biodiversity preservation, land tenure rights, and GHG reduction goals. Governments should work toward international cooperation on these issues in international policymaking venues such as the G7, G20, UN Framework Convention on Climate Change (UNFCCC), UN Committee on Food Security, UN Convention on Biological Diversity, post-2015 development agenda, etc.
- *Continue Research with a Focus on Sustainability.* Research and development of second-generation biofuels should increase but with strong attention to sustainability criteria that can be widely and consistently implemented. Given the volumes required to meet global biofuel demand, even seemingly benign feedstocks can prove unsustainable at large scale.
- *Feedstocks Matter*.[158] As policymakers rethink their biofuels mandates, it is important to pay particular attention to feedstocks and to volumes. If countries are able to produce commercially competitive biofuels from non-food feedstocks in the next ten years, this would transform the current biofuels market; however, as many experts have pointed out, there is a low likelihood of second-generation biofuels being produced in significant quantities soon. Current biofuels production has resulted in large social and environmental externalities, and these will only worsen if first-generation biofuels production continues to increase as expected or if second-generation biofuels result in the same food vs. fuel and other negative impacts as first-generation biofuels. Biofuels are not created equal, and they should not be treated the same.
- *Volumes Are Key*. The United States producing a few billion liters to replace lead in gasoline as an oxygenate may have been warranted, but decades of subsidies and aggressive mandates for approximately 76BL of food-based biofuels continuing on auto-pilot regardless of food or crop prices has led to numerous unintended consequences.

Policymakers now have a choice. Given all we have learned over the past decade about the impacts of biofuels use, it is time to rethink mandates, targets and other subsidies for biofuels, especially those made from crop-based feedstocks or from other sources with large land-use impacts.

Appendix A: Summary Table with Notes

Table 1: Selected Biofuel-Consuming Country Mandates through 2025

(in billions of liters)

Country	Mandate/target			Current Consumption		Mandated Increase	Transport Fuel Demand Growth through 2025	Added Volume, Full Mandate+ Demand Growth	Projected Demand 2025	
	Timeframe	Ethanol	Diesel	vol	% fuel supply	%	%	vol	vol	% increase
United States	2022	72 BL	3.8 BL	62.9		21%	N/A	13.1	**76.0**	**21%**
European Union	2020	10.0%		18.7	5.0%	72%	-8%	12.1	**30.8**	**64%**
Brazil	2014	25.0%	7%	29.0	27.5%	0%	36%	12.2	**41.2**	**36%**
Argentina	2014	5%	10%	2.0	7.6%	25%	57%	1.3	**3.2**	**64%**
China*	2020	15%	-	3.6	8-12%	50%	59%	3.9	**7.5**	**109%**
India	2014	5%	-	2.3	2.1%	42%	47%	2.0	**4.3**	**89%**
Indonesia	2025	15%	20%	0.8	3.0%	795%	65%	7.1	**8.0**	**860%**
Total Selected				**119.2**				**51.6**	**170.9**	**43%**

Sources:
All current volumes are taken from the most recent US Department of Agriculture (USDA) GAIN reports unless otherwise noted.
Transport fuel demand growth rates are calculated from IEA's New Policies Scenario except for Indonesia and Argentina.
Ethanol and diesel demand estimates for Argentina, for 2015-2024, are taken from USDA's GAIN Report for Argentina, 2014.
Ethanol and diesel demand estimates for Indonesia, for 2015-2024, are taken from USDA's GAIN Report for Indonesia, 2014.
Diesel consumption for India is derived from USDA's GAIN Report for India, 2013.
Current volumes for the US are the Environmental Protection Agency's (EPA) 2013 mandated biofuels volumes.
*China's mandate is for nine provinces only, representing just 1.1% of current fuel use and a projected 1.3% in 2025.

Notes/Assumptions:

(1) The US is assumed to meet slightly over half (20 billion gallons) of its 36 billion gallon Renewable Fuel Standard (RFS) mandate by 2022 (and 2025 for this analysis). We assume the US meets its 15 billion gallon mandate for corn starch ethanol, 1 billion gallon mandate for biodiesel (which could be increased by US EPA), and that the remaining 4 billion gallons are met by imported sugarcane ethanol (total of 20 billion gallons). Again, the biodiesel target could be increased by EPA, leading to less imported sugarcane ethanol, but both are considered first-generation biofuels in this analysis. We assume the remaining 16 billion gallons, mandated to be filled with cellulosic ethanol, a second-generation biofuel, are not produced due to technological and economic challenges, and that EPA waives down this mandate, leaving just 20 billion gallons of the mandate to be fulfilled.

(2) EU estimate for "mandated increase" assumes that adjusting for double-counting for advanced fuels the effective mandate would be 8.6%. At this writing,, the proposed reform to 7% from crop-based sources had not been approved.

(3) Consumption numbers for Brazil are calculated based on the 25% ethanol mandate, the latest figures available. Mandate applies to only a small portion of ethanol market, but we estimate total projected demand for all biofuels driven not by mandate but by demand growth including all biofuel types.

(4) Calculated Argentina's transportation demand differently because USDA estimates a change in ratios of gasoline to diesel. Calculated separate demand increases for gasoline and diesel, which has implications for ethanol and biodiesel use.

(5) China has a 10% mandate and a 15% target but for only nine provinces. We assumed China would not expand beyond the nine provinces and would meet its 15% target (and used this as its mandate) because past targets have systematically been met. China's transportation fuel demand growth rate in affected provinces is assumed to be the same as China's overall growth rate. Where uncertainty in current implementation of mandates exists, the midpoint of the range was used for calculations (e.g. China 8-12% current ethanol blend was calculated at 10%).

(6) Only considered India's 5% bioethanol mandate to be binding, so we did not assume the country's 20% bioethanol and 20% biodiesel targets would be filled.

(7) Indonesia currently has a 5% mandate for biofuels, but also has more aggressive targets of E15 and B20 by 2025. The higher targets are used in this analysis.

(8) All transportation growth is annualized on a linear basis from IEA and USDA growth rates.

(9) The growth rate for Chinese transportation fuel demand is for the entire country though the mandate covers only nine provinces.

Appendix B: Global Biofuel Mandates

OECD

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
OECD	**Various**	**Implemented, or on track to be fully implemented by target dates.**	**Various**	**Various. Both domestically produced and imported.**
United States	137BL of biofuels by 2022 divided into requirements for first generation, advanced and cellulosic fuels.[159]		21% growth to meet non-cellulosic mandate by 2022. Current production of 58BL of ethanol (corn and sugar) and 5BL of biodiesel.	Corn, soy, animal fat, sugar cane (imported).
Canada	5% national bioethanol mandate; 2% national biodiesel mandate; up to 8.5% bioethanol mandates in four provinces.	Fully implemented.	None.	Corn, wheat, canola oil.[160]
European Union	10% of transportation fuels from renewables by 2020 but proposal for only 7% from food-based feedstocks. Projected volumes for full implementation would be around 30,000ktoe.[161]	In 2012, most countries were on track to meet the 2020 targets. Projections show the EU will fall short of its 2020 goal by approximately 1/3 using around 20,000ktoe in 2020.[162]	92% increase required to meet 10% mandate, which accounts for a drop in transportation demand.	Varies from country to country.
Germany		7-8% of transportation fuel from bioethanol in 2009.[163] 2.6 billion tonnes of biodiesel in 2010; insolvency in companies is leading to lower numbers in recent years.[164]	2-3% from EU 2020 target.	Vegetable oil.[165]
United Kingdom		3.45% of transport fuel from bioethanol.[166]	6.55% from EU 2020 target.	Wheat and sugar beets.[167]

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
Spain	Revised targets down to 4.1% for all bioenergy and 3/9% for bioethanol in 2013.[168]	Biodiesel blending has not been enforced since 2010. Revised targets were met in 2013.[169]	6.1% from EU 2020 target.	Domestic oil seeds, imported palm, and animal fat.[170]
France	Current target of 7%.[171]	5.78% from bioethanol and 7.07% from biodiesel.[172]	4.28% from EU 2020 target.	Corn and sugar beets.[173]
Italy		4% of transport fuel from bioethanol in 2009.[174]	6% from EU 2020 target.	Rapeseed, soy, palm, cereal and wine byproducts.[175]
Sweden		Reached target of 10% biofuels in transport fuels.[176]	Met EU 2020 target.	Rapeseed and wood pellets.[177]
Australia	New South Wales 5% ethanol mandate and 2% biodiesel mandate.[178]	Implemented. 6% ethanol mandate adjusted down to 5% until more local supplies are available.[179]	None.	
New Zealand	Biofuel mandate allowed to expire.[180]	The bioethanol excise exemption remains, but other subsidies have been allowed to expire.[181]	N/A.	
South Korea	2% biodiesel mandate.[182]	Since 2010, held production at 400,00kL/year.[183]	None.	
Mexico	2% ethanol mandates in two provinces.	Not fully implemented.	Unclear.	
Chile	5% ethanol and biodiesel target.	Target not met.	Unclear.	Import dependent. No significant domestic production.
Turkey	6% ethanol mandate and 1% biodiesel mandate.[184]	Implemented. Biodiesel blend rate exceeded.[185]	Ethanol usage must double.[186]	Waste cooking oil and sugar beets.[187]

Producers Meeting High Mandates

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
	Greater than or equal to 10% ethanol or biodiesel.	**Fully implemented or close to full implementation.**	**Various.**	**Various.**
Argentina	10% biodiesel mandate, 5% ethanol mandate.[188]	Implemented, average national ethanol blend of 7.6% in 2013 (600 million liters).[189]	64% increase to meet current mandates in 2025, which includes increased transport demand.	Soy, sugarcane.[190]
Brazil	25% ethanol blend mandate, 7% biodiesel mandate.[191]	Fully implemented.	36% increase required to maintain current blend level with increased transport demand by 2025.	Sugarcane and soy.
Colombia	8% or 10% ethanol mandate depending on stocks.	Fully implemented.	None.	Sugar cane and palm.[192]
Ecuador	5% biodiesel mandate to increase to 10%; 10% ethanol mandate.[193]	Mandates were being filled as of 2012.[194]	None.	Palm, sugar cane, jatropha.[195]
Paraguay	25% ethanol mandate, but the Senate has passed an increase to 27.5%; 1% biodiesel mandate.[196]	Fully implemented.	None.	Sugarcane.
Peru	7.8% ethanol mandate; 5% biodiesel mandate.[197]	Implemented.	None.	Primarily importing Argentine biodiesel.[198]
Philippines	10% ethanol mandate; 2% biodiesel mandate.[199]	Implemented, but difficulty reaching the 10% ethanol mandate,[200] planned expansion to 5% biodiesel is not yet implemented.	None. 3% for proposed biodiesel expansion.	Palm and coconut oil.
Zimbabwe	15% ethanol mandate (recently up from 5%).[201]	Forced to scale back 20% mandate due to lower production.[202]	None for adjusted mandate.	

Producers Proposing High Mandates

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
	Mandates over 5%.	**Not yet fully implemented or level of future implementation is unclear.**	**Various.**	**Various.**
Costa Rica	7% ethanol mandate; 20% biodiesel mandate.[203]	Unclear: seemingly not fully implemented.[204]	Unclear.	Jatropha,[205] palm, sugar cane.[206]
Panama	Currently 5% ethanol mandate to rise to 10% by 2016.	Unlikely to reach 10% by 2016 due to lack of capacity.[207]	5%.	Sugarcane.
China (PRC)	10% biofuels mandate by 2020; 15% biofuels target by 2020.[208]	E10 required and implemented in 9 provinces.[209] Actual blend rate reported between 8 and 12%.[210]	109% increase required to meet 15% biofuels target, which includes expected increased transport demand.	Grain, waste cooking oil, investing in sorghum, cassava and other food crops that can be grown on marginal land.[211]
India	5% ethanol mandate (reduced from 20% target); 20% biodiesel target.[212]	Projected at 2.1% in 2014 and 2.5% in 2015.[213]	89% increase to meet 5% ethanol mandate only by 2025, which includes expected increased transport demand.	Sugarcane, multiple feedstocks for biodiesel moving from jatropha to tree nuts.[214]
Indonesia	5% biofuel mandate; 15% ethanol target and 20% biodiesel target by 2025[215]	4.5% of biodiesel mandate met, but 0% for ethanol.	945% increase to meet full targets and future projected demand for transport fuel.	Palm.
Malaysia	5% biodiesel mandate[216]	Not yet fully implemented throughout the country. Target of this year for implementation in all locations.[217]	Unclear. None if goal is met this year.	Palm.
Thailand	10% biodiesel target by 2019.[218]	Level of implementation depends on palm oil supplies.	Unclear.	Palm.
Vietnam	5% ethanol mandate to go into effect at the end of 2014.[219]	Has not yet begun.	N/A	

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
Malawi	10% ethanol mandate.[220]	Only major producer of ethanol in Southern Africa. No readily available data on steps it has taken to meet the mandate.	Unclear.	Jatropha[221] and sugarcane.

All Other Mandates

Country/ Region	Mandate/Target	Level of Implementation	Anticipated Growth to Reach Mandate (%)	Primary Feedstock
Jamaica	10% ethanol mandate[222]	Unclear.	Unclear.	
Uruguay	2% biodiesel mandate from domestic biodiesel; thought will move to 5% ethanol mandate.[223]	Unclear.	Unclear.	Soy, tallow, sugarcane.[224]
Fiji	Voluntary 10% ethanol blend, 5% biodiesel blend.[225]	Unclear.	Unclear.	Unclear.
Taiwan	1% biodiesel mandate.[226]		None.	
Angola	10% ethanol mandate.[227]		Unclear.	Sugar.[228]
Ethiopia	5% ethanol mandate.[229]	Some biofuels plants online, the majority are pre-implementation.[230]	Unclear.	Sugar and jatropha.[231]
Kenya	Kisumu has a 10% ethanol mandate.[232]	Not implemented. Mandate remains a target.	Unclear (close to 10%)	Jatropha.[233]
Mozambique	10% ethanol mandate.[234]	Have created a legal framework, but not fully implemented.[235] 36MnL/year average 2010-2012.[236]	Unclear (close to 10%)	
Nigeria	10% ethanol target.[237]	Not implemented.[238]	Unclear (close to 10%)	
South Africa	Planned 2% ethanol targets and 5% biodiesel targets to begin in 2015.[239]	367MnL/year ethanol production average 2010-2012.[240]	N/A	Sugar cane, sugar beet, sweet sorghum, soybeans, sunflower seed, canola oil and vegetable oil.[241]
Sudan	5% ethanol mandate.[242]	Plans for expanded production. No indication have reached 5%.	Unclear.	Jatropha.

Appendix C: Biofuels Projects in Ethiopia[243]

Table 2: List of biofuel projects in Ethiopia as of December 2012

Feedstock	Project	Investment Type (Public, domestic private, foreign private)	Area (ha)	Location	Current Status of implementation
Sugar cane [3]	Fincha Sugar Factory	Public	21,000	Oromiya	Operational
	Metahara Sugar Factory	Public		Oromiya	Operational
	WONJI / SHOA SUGAR FACTORY	Public	16,000	Oromiya	Operational
	Tendaho Sugar Development Project	Public	50,000	Afar	Implementation
	Wolkaiyt Sugar Development Project	Public	45,000	Tigray	Implementation
	Kuraz Sugar Development Project	Public	175,000	SNNPR	Implementation
	Kessem Sugar Development Project	Public	20,000	Oromiya	Implementation
	Belles Sugar Development Project	Public	75,000	Amhara	Implementation
	BDFC Ethiopia Industry P.L.C	Foreign	18,000	Amhara	Pre - implementation
Castor	Acazis Ethiopia PLC	Foreign	15,000	Oromiya	Operational
	Global Energy Ethiopia	Foreign	2,700	SNNPR	Implementation
	HUSEYIN POLAT	Foreign		Oromiya	Implementation
Jatropha	Sun Biofuels Ethiopia/National Biodiesel Corporation	Foreign	80,000	Benishangul Gumuz	Pre - implementation
	Ambasel Jatropha Project	Domestic	20,000	Benishangul Gumuz	Pre - implementation
	Agro peace bio Ethiopia	Foreign	80,000	Multiregional	Pre - implementation
	African Climate Exchange PLC	Foreign	100,000	Multiregional	Pre - implementation
	Energy seeds Ethiopia PLC	Foreign	2	Multiregional	Pre - implementation
	Africa Ethiopia Biomass Energy PLC	Foreign	NK	SNNPR	Pre - implementation
	Ertale Bio Diesel PLC	Foreign	NK	Multiregional	Pre - implementation
	2H 2S International Business PLC	Domestic	100,000	SNNPR	Pre - implementation
	Ethiopia Bio Power PLC	Domestic	NK	SNNPR	Pre - implementation
	Green Energy plc	Domestic	50,000	SNNPR	Pre - implementation
	National Energy PLC	Foreign	NK	Oromiya	Pre - implementation
	OBM Ethio Renewable Energies PLC	Foreign	50,000	Oromiya	Pre - implementation
	F.E.P.E.Amaro Bio-Oil PLC	Foreign	50,000	SNNPR	Pre - implementation
	J.M.B.O Bio Fuel Production PLC	Foreign	2,000	Oromiya	Pre - implementation
	Paul Morrell	Foreign	1,000	Oromiya	Pre - implementation
	Soubra Abdallah Khalid	Foreign	10,000	Oromiya	Pre - implementation
	The Giving Tree Nursery PLC	Foreign	200	Oromiya	Pre - implementation
	Ardent Energy Group,INC.	Foreign	NK	Multiregional	Pre - implementation
	FB BIODIESEL PLC	Foreign	NK	Amhara	Pre - implementation
	Slishi Atile Dessta	Domestic	NK	Addis Ababa	Pre - implementation
	Sayo Biofuel plc	Domestic	NK	Tigray	Pre - implementation

Source: EIA and MoA, Jan 2013
Note: NK - not known

[3] Note that the primary product from sugarcane production is sugar. Ethanol is a by-product made through processing of the molasses.

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