Minimizing Greenhouse Gas Emissions from Bioenergy Production and Use

A STRATEGY FOR THE DAVID AND LUCILE PACKARD FOUNDATION AND THE CLIMATE AND LAND USE ALLIANCE

Peter Riggs, Senior Advisor, April 2014

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EXECUTIVE SUMMARY

Since 2008 the David and Lucile Packard Foundation has been supporting work aimed at reducing greenhouse gas (GHG) emissions associated with international biofuels development. In light of the progress achieved over the past five years, as well as changing market and policy contexts, the Foundation updated its grantmaking strategy during 2013. This document presents the Packard Foundation's bioenergy strategy for 2014 through 2016.

Our strategy on bioenergy reflects our concerns with the potential for the rapid growth of modern bioenergy supply—including biomass and biofuels—to actually increase rather than reduce atmospheric GHG concentrations. Bioenergy has generally been portrayed as a "carbon neutral" source of fuel and actively promoted as an environmentally beneficial replacement for fossil fuels. But improved understanding of the environmental, economic, and social impacts of modern bioenergy use over the past decade has significantly changed perceptions of its suitability as an energy source with respect to different feedstocks, production contexts, and use volumes. In addition, tight food supplies and high food prices have led to debate regarding the degree to which bioenergy demand is competing with food production.

Bioenergy was historically assumed to be carbon neutral based on the notion that any carbon released by the fuel when burned would be taken up by the regrowth of the plant that had been consumed as fuel. Some types of bioenergy fit this category, including sawdust and wood waste and some agricultural residues. These sources of bioenergy—called "residuals"—would not result in a net increase in GHG emissions by 2050 since they would have released carbon dioxide in any event over that time frame. But using crops such as corn, sugarcane, soybeans, and palm oil for bioenergy can result in higher GHG emissions when they accelerate the expansion of agriculture, increasing GHG emissions as forests and other natural systems are converted to agriculture (direct land use change). In addition, where food crop acreage is diverted to energy crop production, that food is generally grown somewhere else to make up the shortfall, which may induce conversion of natural systems into crop acreage, resulting in indirect land use change (ILUC). Measuring ILUC from a scientific perspective is complicated, and the use of ILUC calculations as a basis for policy making remains controversial.

Even when the carbon dioxide emitted during combustion of biomass will be sequestered in the growth of new feedstock, a carbon debt is created during the grow-back cycle of the feedstock, and this debt may persist for decades. This is because carbon is released more rapidly through combustion than when a forest is not logged and trees die and decompose at natural rates. While this does not result in any net increase in emissions over a long time frame, biomass burning results in higher atmospheric GHG concentrations in the short term. (Moreover, the combustion of woody biomass emits more carbon dioxide per unit of energy delivered than the fossil fuels they replace, so sometimes decades of regrowth are required before emissions associated with woody biomass combustion even achieve parity with fossil fuel combustion.)

The long-term goal of the strategy outlined in this document is to assist with the e*mergence of a low GHG intensity global bioenergy industry that is environmentally, socially, and economically sustainable.*

The short-term objectives of the strategy are to:

- *Sharply limit the use of biofuels that result in little or no GHG reductions, and put caps on the use of food-based biofuels.*
- *Establish bioenergy GHG emission reduction and sustainability standards and norms worldwide and ensure that bioenergy standards are not undermined by perverse incentives and subsidies that promote unsustainable production of bioenergy.*

The three-year (2014–2016) outcomes we hope to achieve with this grantmaking strategy follow two approaches: "limit the worst" and "hold the rest accountable for GHG emission reductions and sustainability."

Under the "limit the worst" approach, the objective is to curtail the use of modern bioenergy that results in little or no GHG emissions savings relative to the fossil fuels they replace. Certain types of bioenergy are particularly harmful from the standpoint of emissions, and two fuels stand out as unacceptably high in GHG emissions: corn ethanol and palm biodiesel. Our short-term outcomes under this approach include:

- No further expansion of U.S. corn ethanol
- Advanced biofuels retained in a revised Renewable Fuel Standard 2
- An end to perverse incentives for food-based biofuels
- No demand-side policy incentives are established or allowed for palm oil–based biodiesel
- No policy incentive/subsidies for biodiesel production
- New European Union biofuel standards adopted by member-states
- Establishment of safeguards so that outbound bioenergy investments from the United States meet sustainability standards.

Our focus for the second approach, "hold the rest accountable for GHG emission reductions and sustainability," is on the bioenergy sources that represent a significant percentage of new or total production and are most likely to have net GHG benefits over the coming decade. The Foundation will work to ensure that these fuels meet environmental, social, and economic sustainability standards, including limits on GHG emissions. We go beyond an interest in liquid fuels to include a program focus on bioenergy feedstocks used in the heat and power sectors. Our short-term outcomes under this approach include:

- Bioenergy standards by the Roundtable on Sustainable Biomaterials help to establish global sustainability norms
- Safeguards are established so that outbound bioenergy investments from Brazil meet strict sustainability standards
- Improvements in GHG and land use (ILUC) accounting clarify sustainability trade-offs of bioenergy use
- Sustainability criteria are introduced into national debates on ethanol and biofuel use mandates.

The biggest risk in this overall strategy stems from the uncertainty about whether GHG emission-reduction levels assigned to different biofuels and bioenergy feedstocks are accurate. Some researchers feel that there simply are no GHG savings to be had from a shift to biofuels or biomass burning when those activities are pursued at a scale meaningful for meeting any significant percentage of our future energy needs. Other researchers have focused on opportunities for improving the productivity of pasturelands to develop bioenergy feedstocks. As sustainability and ILUC science improves, including for advanced biofuels, the Foundation will continue to examine its assumptions about the sector overall. These risks are best mitigated through improved research and better uptake of new research by relevant policy makers.

BACKGROUND

Framing the Issue

Biomass-based energy accounts for approximately 10 percent of global primary energy use,[1] most of which involves traditional burning of wood fuels for cooking and heating in developing countries. Modern bioenergy supply—including biomass, biofuels, and biogas—is relatively small, just 1.5 percent of electricity generation in 2010, and 3 percent of liquid fuel demand. However, the use of biofuels has grown rapidly. (See Figure 1.)

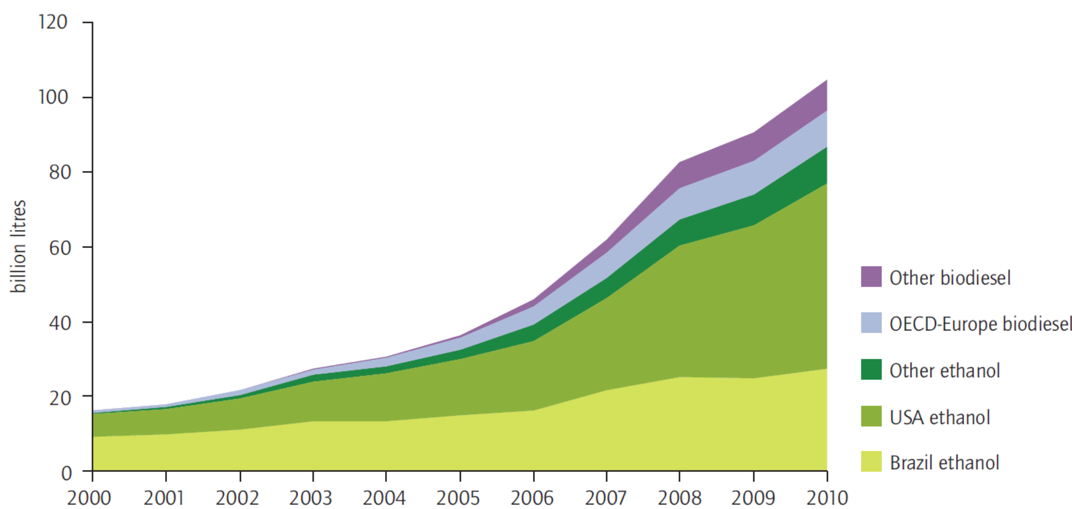

Figure 1. Growth in biofuels uses 2000–2010
http://www.iea.org/publications/freepublications/publication/biofuels_roadmap.pdf, p. 10

Most future energy-supply scenarios suggest significant growth in the amount and proportion of bioenergy used—particularly in scenarios that aim to minimize atmospheric GHG concentrations. For example, in a range of projections developed by the International Energy Agency in 2012, biomass

[1] http://www.iea.org/topics/renewables/subtopics/bioenergy/.

energy is projected to grow three- to fivefold by 2030 (from 72 GW in 2011).[2] Even in a scenario with relatively low growth in overall renewable energy utilization rates, biofuels use increases from 1.3 million barrels of oil equivalent per day (mboe/d) in 2010 to 4.5 mboe/d in 2035, driven primarily by blending mandates.[3]

Bioenergy has generally been portrayed as a “carbon neutral” source of fuel and actively promoted as an environmentally beneficial replacement for fossil fuels. But improved understanding of the environmental, economic, and social impacts of modern bioenergy use over the past decade has significantly changed perceptions of its suitability as an energy source with respect to different feedstocks, production contexts, and use volumes. In addition, tight food supplies and high food prices have led to debate regarding the degree to which bioenergy demand is competing with food production.

Unlike the use of solar energy or wind power, biomass and biofuels generate carbon dioxide (CO_2) emissions as part and parcel of their use. Bioenergy was historically assumed to be carbon neutral based on the notion that any carbon released by the fuel when burned would be taken up by the regrowth of the plant that had been consumed as fuel. Some types of bioenergy fit this category, including sawdust and wood waste and some agricultural residues. These sources—called "residuals"—would not result in a net increase in GHG emissions in 2050 since they would have released CO_2 in any event over that time frame. However, bioenergy often results in net GHG emissions for three reasons.

- Using crops such as corn, sugarcane, soybeans, and palm oil for bioenergy accelerates the expansion of agriculture, resulting in increased GHG emissions as forests and other natural systems are converted to agriculture. These emissions are the result of direct land use changes. In addition, where food crops are diverted to energy use, that food production is generally reproduced elsewhere and in such cases it may induce conversion of natural systems into crop acreage, resulting in indirect land use change (ILUC). Direct competition for feedstocks like corn and sugar as food and as transport fuels has resulted in a strong "food v. fuel" debate about whether, and under what circumstances, it is appropriate to allow use of food-based biofuels. But even the use of non-food-based feedstocks, such as dedicated energy crops, may lead to ILUC and land competition in other parts of the globe. Measuring ILUC from a scientific perspective is complicated, and the use of ILUC calculations as a basis for policy making remains controversial.
- Even in situations where the carbon dioxide emitted during biomass combustion will be sequestered in the growth of new feedstock, a carbon debt is created during the grow-back cycle of the feedstock, and this debt may persist for decades.[4] This is because carbon is released more rapidly through combustion than when the forest is not logged and trees die and decompose at natural rates. While this does not result in any net increase in emissions over a

[2] http://www.ren21.net/Portals/0/REN21_GFR_2013.pdf, Table 4, p. 53.
[3] http://www.worldenergyoutlook.org/media/weowebsite/2012/WEO2012_Renewables.pdf, p. 211.
[4] Moreover, the combustion of woody biomass emits more carbon dioxide (CO_2) per unit of energy delivered than the fossil fuels they replace, so sometimes decades of regrowth are required before emissions associated with woody biomass combustion even achieve parity with fossil fuel combustion.

long time frame, biomass burning results in higher atmospheric GHG concentrations in the short term.

- Net GHG emissions must account for the distance a feedstock travels for processing and eventual use and for the efficiency of the end-use power facility. Bioregional approaches to fuels development are thus more likely to be appropriate from a GHG emissions savings perspective. The efficiency of new biomass power plants, as well as the efficiencies associated with plant conversions to enable mixing (co-firing) of biomass and fossil fuel feedstocks, must also be taken into account.

The potential GHG benefits of using biomass energy vary enormously. Expansion in biomass energy use could result in reductions in overall emissions compared with fossil fuels if first-generation crop-based biofuels are avoided and if biomass energy is limited to waste streams (residuals). But it could result in a significant increase in emissions if new biofuels mandates are met with first-generation, food-based biofuels like corn ethanol and if expanding biomass energy demand results in an increase in timber harvests to meet the demand for woody biomass. Sitting between these two extreme scenarios are three important questions regarding crop acreage dedicated to energy: From a life-cycle GHG emissions perspective, are the alternatives better than food-based biofuels? Are they displacing food production and causing direct land competition and/or high levels of ILUC? What impacts do they have on biodiversity and ecosystem function?

Projections of net GHG savings from bioenergy use in 2020, 2030, and 2050 depend largely on the set of assumptions built into the models used to project the savings; as a result, different national and international agencies have arrived at very different conclusions about the desirability of encouraging biofuels. For example, the International Energy Agency's BLUE Map Scenario looks out to 2050 with an "all [renewable energy] options pursued vigorously" approach. The agency projects that biofuels could avoid around 2.1 gigatons (Gt) of CO_2 emissions annually when produced sustainably. The biggest factor in securing such reductions is the substitution of second-generation fuels for feedstocks that are currently most prevalent. A study focusing on emission reductions in the United Kingdom suggests that an E20 blend (20 percent ethanol) using cellulosic feedstocks would result in a 9 percent reduction in emissions by 2030 compared with a fossil-fuel-based business as usual scenario.[5] Both of these studies foresee a shift to much better biofuel feedstocks.

On the other hand, an expansion of existing first-generation biofuel use could lead to net increases in GHG emissions. For example, the life-cycle GHG emissions of corn ethanol used in the United States were higher than gasoline in 2012 and are projected to be even higher in 2017.[6] Similarly, European Union (EU) data from early 2012 that included ILUC calculations showed that palm biodiesel emitted 17

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[5] Element Energy, "The Role of Biofuels Beyond 2020," http://www.element-energy.co.uk/wordpress/wp-content/uploads/2013/09/20130916-Element-Energy_Role-of-biofuels_FINAL.pdf. Cellulosic biofuels are made from nonedible plant biomass.

[6] Environmental Protection Agency (2010), Renewable Fuel Standard Program (RFS 2) Regulatory Impact Analysis, cited in Faber, 2013. http://democrats.energycommerce.house.gov/sites/default/files/documents/Testimony-Faber-EP-Renewable-Fuel-Standard-Stakeholder-Perspectives-2013-7-22-23.pdf.

percent more GHG per unit energy than crude oil as a feedstock.[7] (See Figure 2.) In conclusion, GHG emissions savings from biofuel use will not be achieved with fuels based on corn and palm oil,[8] and even the better second-generation feedstocks may not allow countries to bank GHG emission reductions at the scale of use anticipated.

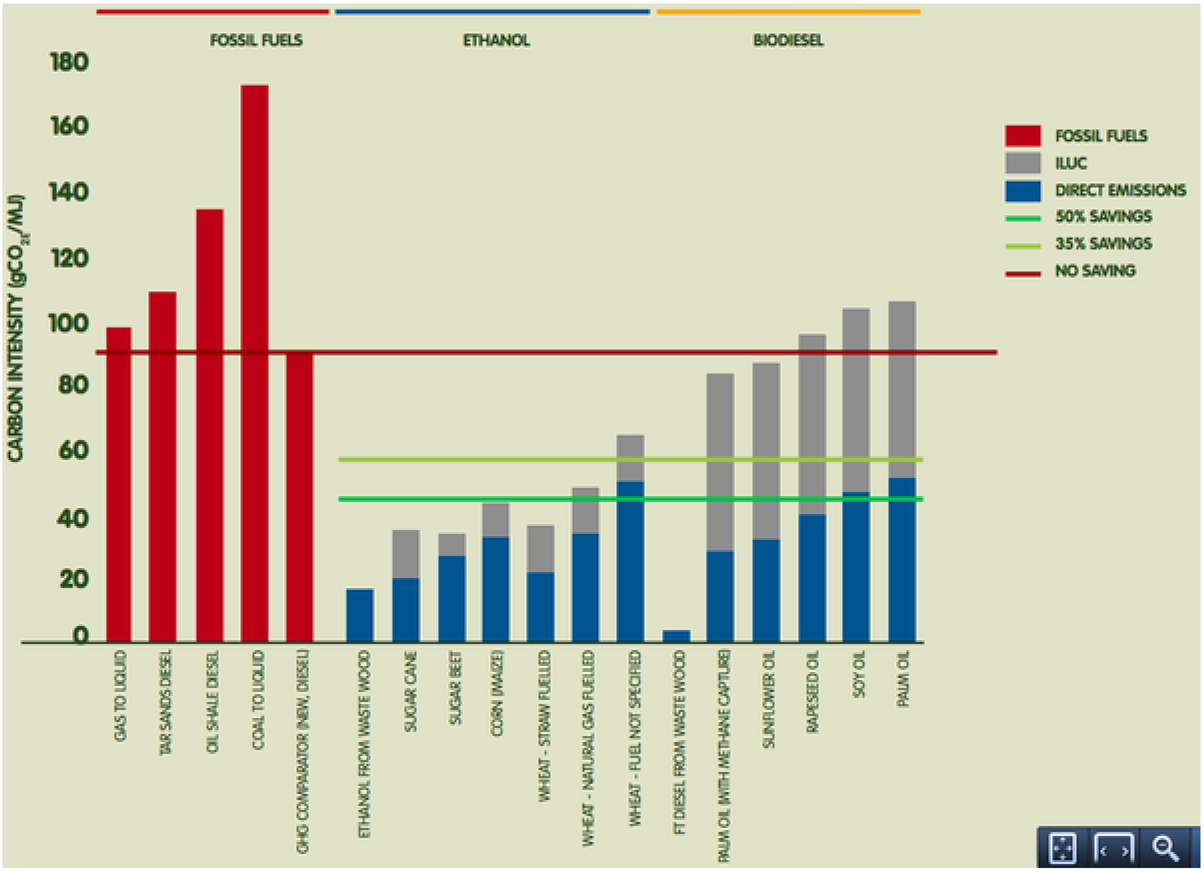

Figure 2. Carbon Intensity of Fuels, with Indirect Land Use Change calculations. Adapted by the European Union from IFPRI data.

[7] Expressed as g of CO_2 per megajoule energy; percent calculated from data obtained by Euroactiv. Current European Union (EU) national Renewable Energy Action Plans would result by 2020 in 25M tons of biodiesel use from vegetable oil (rapeseed, soy, palm oil).

[8] Corn performs poorly as a feedstock from a "net energy balance" perspective because of the inputs necessary to grow the crop and the nature of the feedstock conversion process. Biodiesel made from tropical oil palm production often leads to very high and very long "carbon debts," since palm oil plantations displace tropical rainforest acreage or, worse, are sited atop peat soils associated with exceptionally high GHG emissions when disturbed. Soy biodiesel's net energy balance and indirect land use change (ILUC) numbers depend greatly on production conditions. Sugarcane ethanol is a better performer from a "carbon debt," GHG mitigation perspective, but sugarcane lands used for ethanol compete with food crops, and in some areas new plantings are contributing to tropical deforestation through indirect land use change. "Next-generation" biofuels from non-food feedstocks have much lower emissions than "first-generation" fuels: 80–90 percent better than oil palm and soy, 50 percent better than corn, and even 10–20 percent better than sugarcane feedstocks at current utilization rates. These figures are presented in Table form in Appendix 2.

The use of biomass in the power sector can also result in a wide range of net GHG emissions. For example, biomass energy derived from genuine waste products that would otherwise end up in landfills may provide a net carbon benefit by preventing methane emissions. Woody biomass use stacks up well against coal when long time frames are used to calculate net GHG emissions. The National Renewable Energy Lab in the United States calculated that a biomass-fired integrated gasification combined cycle system using a biomass energy crop has just one-twentieth the global warming potential of a conventional coal plant.[9] However, biomass is increasingly being co-fired with coal, possibly extending the lifetime of this dirty energy infrastructure. When compared with alternative sources of power, such as other renewables or natural gas, the life-cycle emissions savings of woody biomass depend significantly on the type of feedstock used (short-rotation coppiced woody biomass being much better than straw, for example) and on how indirect land use change is treated in the calculations.

Governments have crafted their biofuels policies partly in response to the overall emissions profiles associated with different feedstocks as well as with levels of use. GHG emission reduction is an explicit goal in the biofuel use mandate of the U.S. 2007 Energy Independence and Security Act, known as the Renewable Fuel Standard 2 (RFS2). The United States mandated the use of 15.2 billion gallons of biofuels for transportation in 2012, growing to 36 billion gallons by 2022, with more than half of the growth to be met with advanced biofuels and with one-third of the total amount of biofuels originating from cellulosic ethanol production.[10]

The European Union's Renewable Energy Directive has two utilization targets: 20 percent of the final energy use of the whole economy should come from renewables and 10 percent of the energy used in transport should come from renewables, with the latter target counting toward the overall 20 percent target. In the EU, there are no specific volume targets for the use of biofuels. However, as in the United States, the science undergirding EU policies is based on modeling that shows reductions in life-cycle GHG emissions from the use of biofuels, and thus their use is encouraged. A separate set of EU policies, the Fuel Quality Directive, states that EU biofuels must meet a 35 percent GHG emission reduction target compared with fossil fuel equivalents.[11] For biomass, the European Commission recommends that member-states adopting national sustainability schemes for solid biomass should follow the GHG savings targets set for biofuels.[12] This recommendation for biomass is not a binding requirement, as it is for biofuels. In the recent publication *Biomass Role in Achieving the Climate Change & Renewables EU Policy,* the EU acknowledged the risk of pushing the less sustainable and cheaper resources to the electricity and heat sectors," which can end up increasing unsustainable biomass use.[13]

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[9] Margaret Mann and Pamela Spath, "A Comparison of the Environmental Consequences of Power from Biomass, Coal, and Natural Gas." See http://bioenergykdf.net/sites/default/files/zpdfzholderz/NREL_Data/KC_091102094517.pdf.
[10] See http://www.iea.org/co2highlights/co2highlights.pdf, p. 21.
[11] The 35 percent improvement over fossil fuel equivalent ramps up after 2017, after which time biofuels will need to show at least a 50 percent improvement. We are grateful to Trees Robijns and the staff at Birdlife Europe for helping us understand these targets and policy interactions.
[12] See eur-lex.europa.eu/LexUriServ/ LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF.
[13] See http://www.biomassfutures.eu/public_docs/final_deliverables/WP5/D5.2%20Scenario%20set%20up.pdf.

In sum, a future with an expanded use of bioenergy may be beneficial from a climate standpoint, with annual emission reductions measuring in the gigatons of CO_2e by 2050, but it could also be harmful, causing equivalent increases in GHG emissions while also harming food security and local livelihoods. There are few areas of climate and energy policy where getting the policies right will have such a profound impact on climate and livelihoods.

The Packard Foundation's Work on Bioenergy

In 2008, recognizing the risks associated with bioenergy development, the Packard Foundation began supporting work to reduce GHG emissions from bioenergy, with an initial focus on biofuels. The biofuels industry was quite young when we initiated our grantmaking, and there was a unique opportunity to establish sustainability norms in the early stages of growth in the production of a new commodity. Hence, the Foundation pursued two main approaches to reduce GHG emissions associated with international biofuels development:

- Establishing a set of standards or norms for sustainable biofuels—biofuels that have lower life-cycle GHG emissions than fossil fuels and also meet other social and environmental sustainability criteria—and convincing governments and businesses to adopt those standards in their purchasing or regulatory decisions.
- Doing research and public outreach aimed at eliminating public policy incentives, tax breaks, and subsidies for the use of high-carbon biofuels in two of the world's largest biofuel markets—the United States and European Union.

Given the changes that have taken place in policy and the market for biofuels and bioenergy, the Foundation has reviewed the assumptions behind its initial biofuels strategy and updated the strategy to better fit current needs and opportunities. The most significant change is a broader programmatic focus on bioenergy, including biomass burning and biofuels.

The revised strategy responds in particular to six important policy changes and market developments that have reshaped the bioenergy landscape over the past five years.

- ***Ethanol use reached the "blend wall" in the United States in 2013, meaning that the total production volume of ethanol that can be blended (at the 10 percent level) into national fuel supplies has been reached.*** This means that refiners have secure access to a domestic blending product at relatively low cost; however, virtually all of the ethanol used in the United States comes from corn, a feedstock that falls far short of true sustainability based on measures of meaningful GHG emission reductions. Corn continues to receive price supports via continued direct payments and subsidized crop insurance, even though the blending credits and other subsidies for corn specifically as a liquid fuel feedstock have been removed. Corn ethanol's "hegemonic" position within the U.S. biofuels market continues to crowd out advanced biofuels, which would be more competitive if there were a formal carbon price associated with the GHG emission profiles of all fuels. In our view, the policy approach taken by the State of California—developing methodologies for cross-comparison of the GHG reduction performance of all fuel feedstocks—is a more rational approach for assessing trade-offs associated with biofuel use. We expect that advanced biofuels' comparative advantage from a GHG emissions standpoint would further increase if a greater percentage of the U.S. fossil fuel supply came from "tar sands" oil and other dirtier, unconventional sources.

- ***European Union bioenergy policy has shifted away from food-based feedstocks for biofuels.*** Bioenergy campaigners in Europe expect a cap on the use of food-based biofuels to be enacted in 2014–2015, most likely at 6 or 7 percent of total fuel use. This will likely steer investment away from first-generation fuels and toward feedstocks with better GHG emission profiles. However, food-based biofuels as a percentage of total use are currently well below even the 6 percent figure in most European countries. Hence, growth in use of these biofuels is still expected between now and 2020.

- ***The EU is promoting the use of biomass energy at a level that may significantly increase GHG emissions from the sector*.** Europe has a relatively aggressive approach to climate change mitigation, with the EU seeking to source 20 percent of its primary energy needs from renewable energy technologies by 2020. More than half of that 20 percent target is expected to come from burning biomass in power plants, most of which originates from woody biomass. The utilization target was crafted at a time when it was assumed that most biomass demand could be met from waste products. In fact, the volume of woody biomass required to meet 2020 utilization targets exceeds sustainable wood harvests on the continent eight times over. At these larger volumes, waste products cannot meet the demand and thus a 50 percent reduction suggested, but not required, by Brussels becomes harder to achieve. Europe is home to 80 percent of the world market for wood pellets. European buyers claim that a large portion of the wood supply they import is post-harvest mill waste, but the volume of clear-cut logging and the removal of whole trees now taking place in the American South to meet European demand belies that claim.[14] Trees represent a renewable feedstock, but logging forests or plantations for biomass burning creates a 30- to 50-year carbon debt relative to burning fossil fuels, and it may take more than a century for regrowth to achieve carbon neutrality.[15] Many scientists believe it will not be possible to achieve the projected volume of biomass utilization while still targeting a 50 percent improvement in GHG performance.[16] However, the Union of Concerned Scientists has argued that it should be possible for the United States to meet its biomass use demands with sustainable sources.[17]

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[14] See, for example, http://www.charlotteobserver.com/2013/08/28/4268559/conservationists-report-links.html.
[15] See http://iet.jrc.ec.europa.eu/bf-ca/sites/bf-ca/files/files/documents/eur25354en_online-final.pdf.
[16] For example, the United States currently exports approximately 2 million MT of pellets to Europe each year, but Europe projects the need to import some 40 million MT annually by 2020. See http://www.renewableenergyworld.com/rea/news/article/2012/06/where-do-all-the-wood-pellets-go. If a significant fraction of Europe's demand were to be met from U.S. forest biomass, that demand could dominate production. Because biomass targets could drive a real erosion in the GHG mitigation profiles of feedstocks, with more harvest of mature forest to supply demand, the overwhelming majority of respondents commenting on the Biomass Role paper (op. cit. note 6) argued for extending the EU sustainability scheme now covering fuels to the heat and power sectors as the best way to ensure net GHG mitigation benefits from biomass.
[17] See http://www.ucsusa.org/assets/documents/clean_vehicles/Biomass-Resource-Assessment.pdf. This assessment excludes the use of whole trees, instead suggesting that the target can be met primarily from use of

- ***Brazil is actively engaged in the promotion of ethanol through advantageous trade and investment arrangements, as part of its "soft-power" economic diplomacy with the rest of the world.*** Brazil's current heavy reliance on biofuels in its transport sector is based on a quarter-century of policy continuity encouraging sugarcane ethanol production. Brazil's recent ethanol boom took place against a background of an across-the-board boost in rural incomes, although the degree to which the ethanol boom contributed to Brazil's impressive anti-poverty performance over the last decade is contested. With active diplomatic support and financing from the government, Brazilian companies have become major investors in ethanol production in Africa and Central America. Most of the ethanol produced in these regions is destined for industrial-world markets, and Brazil's overseas bet on ethanol is already generating "food v. fuel" conflicts.[18]

- ***The mandated demand for biofuels may significantly exceed the amount that can be sustainably produced with today's technologies.*** More than 50 countries have mandated or promoted biofuel blending to displace oil in domestic transport fuel supplies, typically as a means to reduce dependence on foreign oil imports and in some cases to prop up domestic crop prices.[19] Summed together, those mandates would drive a tripling of biofuel use, from 1.3 million barrels of oil equivalent per day in 2010 to 4.5 mboe/d in 2035.[20] Opinion is divided as to how much GHG emissions savings this tripling of biofuel use would actually represent. The International Council for Clean Transportation (ICCT) suggests a global sustainable supply of biofuels at 9.3 Mboe/d,[21] centered on highest-yielding cellulosic fuels under strong land protections, noting that "achieving bioenergy utilization at the level envisioned…would require strong government commitment."[22] Opinion is further divided on whether that tripling of biofuel use would push food prices out of reach for millions of people. The World Resources Institute estimates that fulfillment of these 50+ national biofuel mandates could require the diversion of more than a quarter of the world's croplands for biofuel feedstock production. Unlike ICCT's work, WRI's data assume status quo policy—a ramp-up of the current mix of feedstocks and weak land protections.[23]

- ***There is a limited potential for truly sustainable forms of biomass utilization from municipal solid waste and wood waste***. There is simply no possibility that these "after-market" waste streams can respond to the huge increases in projected demand in Europe, let alone if volume-use standards for biomass were adopted more broadly around the globe. Careful consideration

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residuals (wood waste) and corn stover. Doing so would represent a thorough policy makeover, insofar as the current trend is toward increased biomass utilization of whole trees.

[18] See, for example, www.foeeurope.org/press/2010/Jul14_EU_Brazil_biofuels_deal_land_grabbing_charter.html.

[19] See http://www.iea.org/publications/freepublications/publication/biofuels_roadmap.pdf, p. 10.

[20] See http://www.worldenergyoutlook.org/media/weowebsite/2012/WEO2012_Renewables.pdf, p. 211.

[21] S. Searle and C. Malins, ICCT, 2013, presentation at Freedman-Packard Foundation biofuels network meeting.

[22] Stephanie Searle and Chris Malins, *A Reassessment of Global Bioenergy Potential in 2050,* GCB Bioenergy, 2013.

[23] *Creating a Sustainable Food Future*, A working paper for the World Resources Report 2013–14, World Resources Institute, 2013.

of the alternative uses of crop and forest feedstocks in national biomass energy development plans is needed in order to avoid land conversion.

THE FOUNDATION'S STRATEGY FOR MINIMIZING NET GHG EMISSIONS INTENSITY OF BIOENERGY PRODUCTION AND USE

Overview

The strategy outlined in this document focuses on minimizing the net GHG emissions intensity of bioenergy production and use while ensuring that any expansion of bioenergy use is environmentally, socially, and economically sustainable.

The Foundation has chosen to expand its focus to include biomass energy. Previously we focused only on biofuels because the risk of net growth in GHG emissions associated with first-generation biofuels appeared to be much greater than was the case with biomass energy. Modern biomass energy started with a focus on feedstocks with substantially lower GHG emissions than the fossil fuels they replaced. However, the growth of the industry is increasing pressure on forests, with potentially much poorer net GHG emission reduction levels and greater impacts on ILUC and food security. In response, we have expanded our goal to include both biofuels and biomass energy production.

The long-term goal of the strategy is:

> *Emergence of a low GHG intensity global bioenergy industry that is environmentally, socially, and economically sustainable.*

The primary motivation for the Packard Foundation's focus on bioenergy is to support work to mitigate climate change. In addition to reducing GHG emissions associated with bioenergy use, the Foundation's bioenergy goal emphasizes the need to address the other dimensions of sustainable bioenergy use and expansion—namely, limiting impacts on food security, water resources, and biodiversity. We do not want to see sustainable bioenergy competing successfully in the marketplace if that success is attributable to artificially low costs of production resulting from externalizing harms or if it benefits from "accounting errors" that fail to take into account lost food production or indirect land use changes.

In order to achieve our strategic goal, two outcomes need to be achieved:

Life-cycle GHG emissions of bioenergy must be reduced.

- Sources of bioenergy being used as substitutes for fossil fuels that result in net additions to GHG emissions should be removed from liquid transport fuel streams altogether—primarily the production of corn ethanol and palm biodiesel.
- For all biofuels the lifecyle emissions must consider the following: direct land use impacts and indirect land use conversion; the scale of utilization, since a feedstock that may be sustainably used at the 10M metric ton level may not be sustainable when 100M metric tons are being harvested annually; the efficiency of the end-use of that feedstock; and substitutions—whether the biomass is displacing other fuel sources, and what those sources are (such as an existing coal-fired power plant or a new natural gas plant). The goal here is to create financial incentives

and/or government regulations that result in continuous pressure to reduce life-cycle GHG emissions.

- For those sources of bioenergy that have lower emissions than fossil fuels and thus provide net climate benefits, the production of the fuel must not result in other harmful impacts on the environment or on society.

Our focus in this strategy will be on replacing those sources of bioenergy that would result in the greatest net additions to GHG emissions (relative to fossil fuels) over the next decade, advancing policies that incentivize low-carbon fuels, and assisting efforts to improve modeling and understanding of the GHG performance profiles of different feedstocks under different conditions and volumes of utilization.

We will not directly support work to commercialize advanced biofuels. Establishing and promoting global norms and standards for low-emissions sustainable biofuels will contribute to continuous improvements in the emissions profile of biofuels, but the primary driver for reduced GHG emissions will be private sector investment and public policies that place a price on carbon emissions.[24]

For bioenergy that yields net climate benefits, production and use of the most important of these feedstocks[25] must perform well with respect to the social, environmental, and economic parameters of sustainability.

- Impact on food security is the most important sustainability concern, and the most significant research of the impact on food security has been via calculations of food price increases due to U.S. corn ethanol expansion.
- Biomass utilization has far less impact on food supplies, but that use must be considered in terms of the enormous projected increase in demand and the indirect land use change that may result.

The Foundation and our NGO partners can play an important role in promoting the broader environmental, social, and economic sustainability of bioenergy. Because some sources of bioenergy, used at the right scale, can provide significant emission reductions compared with fossil fuels, bioenergy can and should be part of the future energy mix. Using relatively conservative assumptions, such as not counting any energy from the use of forest biomass, the Union of Concerned Scientists calculates that 680 million tons of biomass resource could be available sustainably in the United States for energy production by 2030, equivalent to 19 percent of 2010 U.S. power consumption.[26] But to the extent that low-emission sources of bioenergy are part of the world's energy future, it is essential that they are competing with other sources of energy on a playing field where all sources meet high sustainability standards.

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[24] The Foundation is supporting work to put a price on carbon through our investments in the ClimateWorks Foundation, but not directly through this bioenergy strategy.

[25] Defined as a function of volume of current use *and/or* expected ramp-up of use.

[26] See http://www.ucsusa.org/assets/documents/clean_vehicles/Biomass-Resource-Assessment.pdf. Note that this 680M ton figure is one of availability, not commercial potential. It is not known what percentage of that 680M tons would be commercially viable based on current technologies and energy prices.

Our focus here will be on the sources of bioenergy that appear likely to account for a significant portion of the global fuel mix within the next decade but that also appear to have the most significant sustainability problems, in particular with regards to impacts on food security, water use, and biodiversity.

Approaches, Outcomes, and Objectives of the Strategy

The outcomes and objectives of our bioenergy strategy are shown in Table 1 and described under the two approaches below.

Table 1. Outcomes and Objectives of the Bioenergy Strategy

<table>
<tr><th>Approaches</th><th>Intermediate Outcomes
(2014–2016)</th><th>Objectives (to 2020)</th><th>Goal (to 2050)</th></tr>
<tr><td rowspan="3">Limit the worst</td><td>No further expansion of U.S. corn ethanol
Advanced biofuels retained in a revised RFS2
Perverse incentives for food-based biofuels are ended</td><td rowspan="3">Sharply limit the use of biofuels that result in little or no GHG reductions; caps on food-based biofuels</td><td rowspan="8">Minimize net GHG emissions intensity associated with bioenergy production and use. Ensure that all bioenergy use is environmentally, socially. and economically sustainable</td></tr>
<tr><td>No demand-side policy incentives are established or allowed for palm oil–based biodiesel
No policy incentives/subsidies for biodiesel production</td></tr>
<tr><td>New EU biofuel standards adopted by member-states</td></tr>
<tr><td rowspan="5">Hold the rest accountable for GHG emission reductions and sustainability</td><td>RSB bioenergy standards help to establish global sustainability norms</td><td rowspan="4">Establish bioenergy GHG emission reduction and sustainability standards and norms worldwide and ensure that bioenergy standards are not undermined by perverse incentives and subsidies that promote unsustainable production of bioenergy</td></tr>
<tr><td>Establish safeguards so that outbound bioenergy investments by United States and Brazil meet strict sustainability standards</td></tr>
<tr><td>Improvements in GHG and land use (ILUC) accounting clarifies sustainability trade-offs of bioenergy use</td></tr>
<tr><td>Sustainability criteria introduced into national debates on ethanol and biofuel use mandates</td></tr>
<tr><td>Ensure U.S. biogenic carbon rules include emissions reduction and sustainability criteria covering all biomass/bioenergy facilities
Establish absolute limits on whole-tree harvests and biomass removals</td><td>Biomass development in the United States and Europe incorporates GHG emission reduction and sustainability standards</td></tr>
</table>

	EU modifies biomass use targets in power sector to reflect emissions reduction and sustainability criteria		

Limit the Worst

Our objective is to curtail the use of modern bioenergy that results in little or no GHG emissions savings relative to the fossil fuels they replace. As shown in Appendix 1, certain types of bioenergy are particularly harmful from the standpoint of GHG emissions. Two fuels stand out as unacceptably high in GHG emissions: corn ethanol, which has already achieved very high levels of production, particularly in the United States, and palm biodiesel, which has the potential for massive, harmful growth in utilization over the next decade.

Given the specific time horizon and large-scale geographic foci of this strategy, we have chosen to frame the issues and choices in ways that are most politically meaningful. A focus on these specific feedstocks tacitly acknowledges the political terrain in which we are engaged with respect to the way that the RFS2 is structured in the United States and the debate over "food-based biofuels" in Europe. Low Carbon Fuel Standards (LCFS) generally provide a better basis for modeling policy choices than do the volumetric targets found in the RFS2 or the proposed "cap" on food-based biofuels in Europe[27] because the standards require head-to-head comparisons of the GHG emission profiles of both bio-based and fossil fuel feedstocks. The Foundation has provided support to partners for work on California's LCFS. Where possible, we will support work that extends California's pioneering approach.

<u>U.S. Corn Ethanol</u>

We focus on corn ethanol in the United States, including domestic use of corn stocks for ethanol and U.S. promotion of corn ethanol abroad. The United States is by far the world's largest ethanol user. U.S. corn ethanol production is double that of Brazil's sugarcane ethanol. Ethanol is set to consume 25 percent of the U.S. corn crop in coming years.[28] The country devoted 5 billion bushels of corn to ethanol production in 2012, equal to 127 million metric tons—the equivalent of the total harvest of the next three largest players in the global corn market combined (Brazil, Argentina, and the Ukraine).[29] Farmers in all these countries have adjusted to higher corn prices by adjusting crop rotations, converting pasture

[27] This says "generally" because a Low Carbon Fuel Standard (LCFS) that failed to include calculations of ILUC would represent a set-back over volume standards that do. Note also that using an LCFS approach would open the door to at least the possibility of making major improvements in the emission profiles of the feedstocks identified as "bad biofuels," like corn ethanol—which would also shift the political terrain on which our partners are engaged, since the focus then could be on bad corn ethanol production processes rather than opposing use of the feedstock itself.

[28] In 2010, use of the U.S. corn crop for ethanol reached 40 percent. However, ethanol plants produce a valuable by-product, distiller's grain, which is a major component of livestock feed. This by-product is about one-third of the ethanol stream; U.S. Department of Agriculture projections (which do not separate out distiller's grains in calculations of ethanol use) are for roughly 35 percent of the U.S. corn crop to be used for ethanol production. Subtracting out the distiller's grain number, then, we arrive at and use the figure 25 percent of the crop going into ethanol production.

[29] Figures compiled using www.indexmundi.com.

to cropland, reducing fallow periods, and putting new land into production. Broadly speaking, U.S. ethanol demand has buoyed corn prices worldwide.

Consistent with its statutory mandate under the 2007 Energy Independence and Security Act, the Environmental Protection Agency (EPA) adjusted the 2014 use volume targets in the RFS2, revising volume requirements for corn ethanol use downward. The United States is already at the 10 percent blend wall, meaning that corn ethanol by itself can provide 10 percent of U.S. gasoline supply. This move should probably be interpreted more as a concession to reality than a strong political statement.[30] Fortunately, EPA's 2014 rules left the advanced biofuels category alone and adjusted the cellulosic biofuels category in the RFS2 to the reality of current production levels, as opposed to the massively overoptimistic target for cellulosic fuels envisioned by legislators and EPA in 2007, when the RFS2 was created.

EPA's 2014 decisions may have created new uncertainty and new volatility, but even if the RFS2 were repealed and tax credits removed, there would likely be little reduction in corn ethanol production. Now that the investments have been made and the infrastructure created, the marginal costs of production to the industry are relatively low.

Our goal is to prevent further expansion of corn ethanol. This includes rolling back U.S. subsidies for the feedstock, for blending, and for infrastructure and preventing the reintroduction of expired subsidies.[31] We will continue to provide support for state-level efforts to establish Low Carbon Fuel Standards to limit further expansion of corn ethanol and provide incentives for advanced biofuels. It is clear that corn ethanol is now a mature industry, no longer needing the special tax treatments and incentives that have already allowed it to become the "incumbent" North American biofuel. We would like to see corn ethanol targets and incentives stripped out of any revised Renewable Fuel Standard as well as seeing a target for the use of advanced and cellulosic fuels, with their substantially better GHG emission profiles, retained. While the EPA has already approved moving the ethanol blend wall to 15 percent, we believe that substantial technical and infrastructure barriers, coupled with broader understanding of the food security impacts of expanded corn ethanol use, will prevent any early implementation of this new target.

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[30] Nonetheless, some commentators view the action of the Environmental Protection Agency (EPA) as a sellout to the oil companies that would like to eliminate corn ethanol from the national fuel supply. See http://insideclimatenews.org/news/20140210/ oil-industrys-fight-kill-renewable-fuels%E2%80%94and-why-it-may-win. EPA could have pushed the industry to move toward the 15 percent blending target, as allowed under current rules, and required the additional 5 percent to come from "advanced" and cellulosic fuels. Strong opposition from the auto industry and from marine and small engine producers in addition to the fossil fuel industry makes this politically unlikely.

[31] As a private family foundation, we do not advocate for candidates, legislation, or ballot initiatives. The Packard Foundation is permitted to use its funds to influence public policy as long as the activities are outside the definitions of lobbying or are within exceptions created by the Internal Revenue Code and Regulations. There are many activities the Packard Foundation can fund, including research, analysis, data collection, discussions of important broad social and economic issues, project work, and direct service, to name a few. Grantees often have more latitude in what they can do. Grantees that are 501(c)(3) public charities can engage in lobbying activities up to the limits established by the law. The law provides clear guidance on how private foundations can support public charities that lobby. Like many other foundations, we follow those rules when supporting grantees who choose to advocate specific public policies.

Overall, we seek a rightsizing of the ethanol market to acknowledge its important use as an oxygenate—at less than a 10 percent blend. Of course, should advanced biofuels become cost-competitive with corn ethanol, the suitability of those fuels for use as oxygenates should be pursued. EPA has taken a step in the right direction by ratcheting down the amount of corn ethanol covered by the Renewable Fuel Standard in 2014.

The program of export supports for corn ethanol from the United States and the use of public subsidies to support corn ethanol expansion abroad[32] are problematic, particularly if countries are being encouraged to adopt biofuel use targets that allow corn ethanol production and consumption. Thus another facet of the Foundation's strategy is an engagement on the sustainability parameters used by national governments in crafting biofuel use targets. Corn ethanol's "passport to travel the world" should be revoked due to its failure to reduce GHG emissions from liquid fuel use and its direct competition with uses of corn for food.

Palm Biodiesel

Palm oil today is the feedstock for 10 percent of global biodiesel production. In Europe, which uses more than 80 percent of the world's biodiesel, rapeseed is responsible for 70 percent of biodiesel production. Two-thirds of Europe's rapeseed production goes to biodiesel, and the only way in which production of this vegetable oil can expand to meet the expected doubling of total biofuel use in Europe between 2010 and 2020 is for rapeseed's current use in food products to be replaced with palm oil. Recent research suggests that rapeseed as a biodiesel feedstock under most scenarios does not meet the EU's 35 percent improvement over fossil fuel equivalent standard for fuels to qualify under the Renewable Energy Directive.[33] As the International Council for Clean Transportation notes, "expansion in European vegetable oil production has been inadequate to meet biodiesel demand on its own, and palm oil imports have risen dramatically in the same period that biodiesel mandates have been introduced and ramped up."[34] With levels of rapeseed and soy production basically static in Europe, there is tremendous concern that palm biodiesel will be let into the European market, where well over 50 percent of the vehicular fleet runs on diesel, or that food uses for the homegrown feedstocks will be replaced with palm oil, freeing up that acreage for use in biofuels but representing an effective net increase in demand for land planted to oil palm.

Palm oil expansion, especially onto peatlands in Malaysia and Indonesia, constitutes one of the gravest global threats to successful reduction of GHG emissions from land-based sources. Investors expanding oil palm plantation acreage have focused primarily on vegetable oil, food, and cosmetic markets, and only secondarily on biodiesel markets, but that is now changing. In 2013, Indonesia increased to 10 percent (from 7.5 percent) its blending requirement for biodiesel fuels used domestically—and all of that increase is coming from palm oil feedstocks. The impetus for the increased domestic use requirement is the fact that Indonesia's palm oil exports are being squeezed by buyers adopting "no-deforestation" pledges for their palm oil purchases, along with Indonesia's political failure to reform domestic fossil fuel subsidies, since the country is now a net importer of crude oil and since the costs of

[32] See http://www.opic.gov/press-releases/2010/opic-board-approves-60-million-ethanol-project-hungary.
[33] Gernot Pehnelt and Christoph Vietze research, http://pubdb.wiwi.uni-jena.de/pdf/wp_2012_039.pdf.
[34] See http://www.theicct.org/vegetable-oil-markets-and-eu-biofuel-mandate.

imported fossil fuels weigh heavily on national accounts (thus the desire to increase substitution with a "homegrown" product). In addition, a modest portion of Indonesia's electricity capacity is based on burning diesel fuel, and starting in 2014 the government will require biodiesel to be blended into these plants at the 20 percent level.[35]

Both Indonesia and Malaysia have lobbied heavily for national governments to allow palm oil feedstocks to be used in biodiesel production. This has taken the form of direct lobbying of governments as well as threats and bluster in multilateral economic fora. Indonesia and Malaysia have tried to get oil palm products placed on the "environmental goods" list in various trade-negotiating settings, most prominently at the moment in the TransPacific Partnership negotiations that involve the United States. An "environmental goods" designation would allow for early harvest of lower tariffs and increased international market access for palm biodiesel. The attempt to list palm biodiesel as an environmental good has not been supported by Indonesia's and Malaysia's trade-negotiating partners to date, but continued attention here is important.

The Packard Foundation is active in various ways in countering the formidable global warming threat represented by expansion in palm oil acreage, particularly on peatlands. Attempts to limit access for palm biodiesel to existing and new biofuel markets form part of that overall strategy. In the United States, this means work to ensure EPA does not reverse itself and classify palm oil as an acceptable advanced biofuel. In the European Union, it means holding the line on palm oil, preventing its acceptance under the Renewable Energy Directive. In Brazil, it calls into question the use of public funds for expanding oil palm plantation acreage in other countries. Finally, consistent with our emphasis on preventing the global spread of "bad biofuels," the Foundation will work to ensure that palm biodiesel is excluded from the biofuel use mandates being adopted by many middle-income countries. This strategy area involves close coordination with our partners in the Climate and Land Use Alliance.

New EU biofuel standards

Earlier this year the European Union came close to securing a "hard cap" on food-based biofuels at 7 percent of total fuel use by 2020. In fact this target number is still higher than the current use percentage in the EU, so the cap still allows for some growth in utilization of food-based biofuels over the next six years. Nonetheless, it signals to investors looking ahead that first-generation feedstocks have a limited tenure in the EU liquid fuel sector and that productive, longer-term investment should instead be steered toward advanced and cellulosic fuels.

The decision to pursue a cap on food-based biofuels was made at the EU (Brussels) level, although it has yet to be formalized due to a set of parliamentary maneuvers that ended up delaying the final decision until the next European Parliament. (Elections were scheduled for May 2014. Not just the EU Parliament but also the European Commission is a key player in this debate, and it may be even less inclined than the Parliament to push for a cap. Finally, the decision must also be adopted by member-states.) Continued research and advocacy on these issues could help to inform decisions regarding the finalization of a cap at the EU (Brussels) level and adoption of the cap by EU member-states.

[35] See http://www.bloomberg.com/news/2013-11-13/palm-oil-climbs-to-one-week-high-on-increasing-biodiesel-demand.html.

Hold Biofuels and Biomass Sources Accountable for GHG Emission Reductions and Sustainability at Current and Projected Usage Rates[36]

Our focus here is on those bioenergy sources most likely to have net GHG benefits and that represent a significant percentage of total feedstock usage or a significant increment of new feedstock utilization over the coming decade. The Foundation will work to ensure that these fuels meet environmental, social, and economic sustainability standards (including limits on GHG emissions). Note, however, that this Initiative goes beyond an interest in liquid fuels to include an interest in bioenergy feedstocks that are used in the heat and power sectors.

Appendix 2 reviews different types of bioenergy from the standpoint of their likely contribution to the global energy mix in 2020 and the sustainability concerns associated with each. These two parameters indicate a program concern with both volumes of use and sustainability parameters. Increasingly, we understand that the two are interrelated, because very high volumes of use may contribute to much higher ILUC numbers than if the feedstock were analyzed in isolation (without reference to other feedstocks) and without reference to the "carrying capacity" of the global arable land base. This is of particular importance for two widely used feedstocks, one primarily for heat and power and the other for liquid fuels—namely, woody biomass and sugarcane ethanol, respectively.

As described earlier, post-harvest wood waste represents a more sustainable bioenergy feedstock, but it is limited in volume and not a feedstock that can be "scaled up" the way that, for example, energy crops can. Setting biomass use sustainability parameters based on net GHG emissions from post-harvest wood wastes but then requiring that the volumes of biomass actually used will outstrip available post-harvest sources by orders of magnitude negates the validity of the exercise and requires us to focus instead on the emissions associated with induced logging of whole trees to supply this demand.

Unquestionably, sugarcane ethanol's GHG numbers are better than those of corn ethanol under virtually all current political economy conditions and cropping systems. By making ethanol use a cornerstone of its national industrial (and not just fuels) policy, Brazil showed that it is possible to have substantially lower transport-sector emissions relying on domestic feedstocks. Much of this new sugarcane acreage came from rangelands. The deforestation emissions associated with that land use change therefore properly belong to cattle ranching from an earlier generation. When pasture-to-sugarcane is used as the basis for calculating net GHG emissions, it ends up making Brazilian ethanol look good.

However, Brazil is one of very few countries in the world that has had a substantial land frontier over the last 20 years as well as a sophisticated set of poverty alleviation policies in place that allowed for improved income and food security with decreasing deforestation. Ethanol expansion played a

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[36] Accountability can be thought of in four ways. First, accountability can be the attempt to maximize the conversion efficiencies of a feedstock, from field-level productivity to conversion efficiencies right through to the efficiency of the engines or power plants that use that feedstock. Second, accountability can be pursued via certification, with the chain-of-custody and multivariate notions of sustainability that implies. The Packard Foundation's program to date has emphasized these two aspects of accountability. The third form of accountability depends on the volumes of feedstock used. Finally, "accountability" should expand to include food security impacts, and this is a key part of the Foundation's overall tactical engagement on biofuels sustainability.

contested role in rural development strategies during that time in Brazil, [37] while at the same time Brazil and the United States worked to set the stage for the acceptance of ethanol as a global commodity. The serious concern is whether, and how, Brazil's domestic experience with sugarcane ethanol is applicable and exportable to other countries, where conditions of land availability, deforestation, dedicated field-to-pump infrastructure, and food security may be very different.[38]

Sustainability standards and norms

Currently more than 50 countries have biofuel use mandates.[39] What would be the consequences of a Global E-10 world (a global fuel market that was 10 percent ethanol)? Tim Searchinger of Princeton University found that meeting a general global goal of 10 percent of transportation fuel from biofuels by 2050 would require 36 percent of current cropland worldwide and that doing this would deliver just 2 percent of net global energy supplies.[40] A 2011 World Bank working paper provides a more optimistic view, finding that current biofuel mandates and targets could be implemented using current pasture lands exclusively and that although GHG emissions would exceed those of fossil fuels until 2021, the biofuels would provide net savings after that time.[41] Overall, then, the numbers for this sector are highly contested, compounded by the problem of separate modeling of biofuel and biomass uses—since these two market streams "compete" for the same arable land acreage. A strong upward trajectory for biomass use in the power sector, combined with the realization of Global E-10 demand, would put enormous pressures on the global land base.

Two countries are most implicated in the expansion of ethanol and in "lobbying" other countries to set ethanol use targets: Brazil and the United States. Meanwhile, the EU is the major source of demand in global biomass markets, and significant attention will be paid to bringing Europe's biomass demand more in line with sustainable supplies and to extending bioenergy sustainability standards to the heat and power sectors.

Consequently, our overall strategy is to promote the adoption of bioenergy sustainability standards and norms by governments, investors, and business, and we will pursue four outcomes to achieve this purpose.

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[37] See, for example, ActionAid Brazil, "Smoke Screen: the Hidden Story Behind Biofuel Production." See http://www.actionaidusa.org/publications/smoke-screen-hidden-story-behind-biofuel-production.

[38] Consumer-focused subsidies for fossil fuel use may play a positive or negative role with respect to biofuels. Removal of those fossil fuel subsidies makes biofuels look better by comparison, thus expanding biofuel use. Such has been the case with respect to Brazil. Indonesia is looking to decrease its consumer-focused fuel subsidy bill, which is leading to even greater use of palm oil as a biodiesel feedstock—and the emissions associated with producing that feedstock are higher than that of fossil fuel equivalents.

[39] The recently published High Level Panel of Experts study of biofuels, undertaken for the U.N. Committee on Food Security, suggests that 50 countries "have now adopted biofuels policies." See www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-5_Biofuels_and_food_security.pdf.

[40] Presentation by Tim Searchinger, Princeton University, at the Packard Foundation biofuel subprogram partners meeting, May 2013. These numbers are soon to be published in *Science*. The authors assume no yield increases to 2050, so this 36 percent figure may err on the side of pessimism.

[41] G. R. Timilsina and S. Mevel, *Biofuels and Climate Change Mitigation: A CGE Analysis Incorporating Land-Use Change*, World Bank Development Research Group, Policy Research Working Paper 5672, June 2011.

- ***We will work to ensure that sustainability criteria, including GHG emissions reduction criteria, are considered and codified in national bioenergy use targets.*** Research now being done by Packard Foundation partners is just beginning the process of "unpacking" the 50+ national mandates that already exist to see what biofuels are covered (ethanol and biodiesel), whether specific feedstocks are referenced, whether a meaningful distinction has been drawn between first-generation food-based biofuels and advanced second-generation fuels, and whether the policies call for volumetric standards for different biofuels or whether a low-carbon fuel standard covering all feedstocks is used. Our targets for engagement are countries now contemplating bioenergy use targets or in the process of revising those figures, with a bias toward larger countries (which have more emissions at stake) and toward those countries that are part of the Climate and Land Use Alliance's "target geography."

- ***We will work to ensure that subsidies for first-generation biofuel production are curtailed and that public funding support for biofuels is directed toward second-generation fuels or toward improving the overall sustainability standards used by partner countries.*** Our specific interest in this strategy area is examining Brazilian and American ethanol export support programs and reconciling their content with the (voluntary) guidelines established by the U.N. Food and Agriculture Organization and the U.N. Committee on Food Security with respect to responsible investment and land/food rights. Packard Foundation partners may also examine the proliferation of "three-way" deals, whereby Brazil (or others) finances ethanol development in another country, with the off-take from that facility destined for use in industrial countries. Finally, targeted advocacy at G8 and G20 venues will seek to ensure that biofuels are part of these multilateral bodies' discussions of food security.

- ***At the international level, we will continue to promote the adoption of better sustainability standards in key venues, referencing the standards agreed at the Roundtable on Sustainable Biofuels, now the Roundtable on Sustainable Biomaterials (RSB).*** The Roundtable's "high-road" standards should serve as a point of reference in establishing a global norm or set of expectations regarding liquid fuels. In 2013, acknowledging the increased importance of biomass in the global energy picture, the RSB expanded its remit to include attention to "high-road" sustainability standards in the biomass sector. The Foundation will continue to support the RSB as it gets off the ground, expecting the organization to be self-sustaining after 2016.

- ***We will work to improve the sustainability science associated with biofuels and biomass.*** Different researchers assign different values to the net GHG emissions of the different feedstocks. Disagreements center mostly on ILUC measurements. Policy making is difficult under conditions of high uncertainty. The most recent High Level Panel of Experts report on biofuels released by the U.N. Committee on Food Security presented a superb synthesis of existing research on the food-price consequences of ethanol expansion—but it had little to say on GHG matters. The Fifth Assessment of the Intergovernmental Panel on Climate Change may help build better consensus around emission numbers associated with different feedstocks and production pathways and make helpful policy recommendations accordingly. Whatever the case, there is a need for more research and comparative assessments—and the contextualization of bioenergy demand within examinations of competing claims on the global land base (protected areas, croplands, REDD+ project areas, indigenous lands, etc.). We expect to support relevant research and scientific communication opportunities with direct application or input into national deliberative processes regarding biofuel and bioenergy targets and use as well as further research and meetings on the question of bioenergy feedstock demand as a deforestation driver globally.

Biomass Power

The four strategies just described cover both biofuels and biomass because of the increased interpenetration of biofuel and biomass feedstocks. But we will also pursue two strategic approaches specific to biomass.

Cellulosic crops like switchgrass can be converted to ethanol, but this material can also be burned to generate power (and, more efficiently, it can be used in combined heat+power situations). Too often, calculations of "available biomass" are sector-specific—focused only on fuels or only on biomass burning—when the more appropriate picture is one that takes into account cross-cutting bioenergy demand.[42]

The geographic scope of these two biomass-focused strategies is limited to Europe and the United States. In Europe, the EU's Renewable Energy Directive and the Climate Change Directive are on an unanticipated collision course, as policy makers gradually realize that tough sustainability parameters and usage limits will be necessary if the EU takes seriously its suggested pathway of 50 percent improvement over fossil fuel equivalents for use of biomass in the power sector.

Faced with a similar set of decisions in the United States, as required under its Clean Air Act authority, the EPA deferred the development of GHG emission rules for biogenic carbon. The most important near-term objectives in this area are working with the EPA on ways to develop the most appropriate format for new rules on biogenic carbon; marshalling scientific debate and opinion, including through scientific sign-on letters directed at regulators; and the aggressive benchmarking and enforcement of any rules promulgated. Any move to provide biomass burning facilities with a permanent exemption from Clean Air Act provisions on the regulation of carbon pollution would be vigorously opposed.

Our strategy is to:

- ***Ensure that U.S. biogenic carbon rules include sustainability criteria covering all biomass/ bioenergy facilities.*** Spurred in part by the lawsuit challenging the EPA's exempting of biomass facilities from GHG-reduction targets, EPA is soliciting comments and developing rules covering these facilities.[43] We will support grantee-partners' participation in the development of rules.

[42] Even less often are studies conducted that model increased food demand and increased demand for bioenergy together, complicating the effort to derive a better picture of trade-offs and land use change drivers at the global scale.
[43] As noted, it is also possible that EPA would try to issue a blanket exemption for biomass-burning facilities, but this is not defensible from a scientific perspective and from a policy standpoint would be a debacle.

- ***Ensure that the EU revisits its biomass use targets in the power sector to reflect sustainable supply.*** The European Union has implied use targets for biomass but has not yet, as a matter of legal compliance, conditioned those targets on net GHG emissions or other sustainability parameters. Currently, Europe's expansion of biomass use depends on a cheap supply of woody biomass, coming mostly from whole-tree harvests and pelletization of woody biomass from private lands in the southern part of the United States. There is no guarantee that these U.S. lands will be reforested, raising concern that Europe's biomass use policy is reducing an important carbon "sink"—forests in the American South.

Changes from 2008–2013 Strategy

The program envisions nine separate but interrelated strategic foci. The majority show basic continuity with the thrust of the program to date: namely, work on limiting the spread of first-generation biofuels, the creation of international reference standards through the Roundtable on Sustainable Biomaterials, and improvement of the sustainability science for biofuels (and now, biomass). Two strategies are new because they are focused on biomass in the power sector. For six years the Foundation has engaged on biofuels in the United States and Europe, but not previously on biomass.

Noting that the sharpest upward trend in biofuel usage in the coming decade is likely to be in advanced developing countries, the final two new strategies focus on the increasing worldwide spread of ethanol and biodiesel use mandates, for the first time looking seriously at Brazil's role in global ethanol and biodiesel markets.[44]

We conclude that an overall strategy encompassing both biofuels and biomass burning, and focusing on the three biggest national players in global biofuels, better aligns with the reality of global bioenergy development, while at the same time we have chosen the "highest-value targets," expressed as those with the greatest GHG mitigation potential.

RISK ASSESSMENT AND MITIGATION

The biggest risk in this overall strategy pertains to the persistence of uncertainty regarding whether GHG emission reduction levels assigned to different biofuels and bioenergy feedstocks are accurate. Some researchers feel that there simply are no GHG savings to be had from a shift to biofuels or biomass burning when those activities are pursued at the scale meaningful for meeting any significant percentage of our future energy needs. Other researchers have focused on opportunities for improving the productivity of pasturelands to develop bioenergy feedstocks. As sustainability and ILUC science

[44] The strategy does not anticipate any engagement on Brazil's domestic sugarcane sector. Overall, it is clear that Brazil's heavy reliance on sugarcane ethanol has resulted in a transport sector with lower emissions than would be the case if Brazil's vehicular fleet were powered by fossil fuels. However, we also believe that the reasons that sugarcane ethanol demonstrates such impressive GHG reduction numbers in Brazil are unique to Brazil, and unique to a particular historical period in Brazil, and are unlikely to be reproduced in other countries or, frankly, reproduced in the next phase of Brazil's national development. Even now, ethanol as a percentage of total liquid fuel use in Brazil is falling sharply. See http://www.washingtonpost.com/world/brazils-ethanol-sector-once-thriving-is-being-buffeted-by-forces-both-man-made-natural/2014/01/01/9587b416-56d7-11e3-bdbf-097ab2a3dc2b_story.html.

improves, including for advanced biofuels, the Foundation will continue to examine its assumptions about the sector overall. These risks are best mitigated through improved research and better uptake of new research by relevant policy makers.

The Packard Foundation strategy in this field overall assumes an important but limited role for bioenergy in meeting our energy use goals under conditions of overall de-carbonization of energy supplies. That positive role for bioenergy is based on assumptions regarding our technical, political, and investment-risk ability to shift to more-sustainable feedstocks. The assumptions are fairly robust—but not easily achieved. Closing the gap between "business as usual" in biofuel sector development and the positive scenarios for biofuel use as envisioned by the International Energy Agency (among others) is largely a policy matter, and the Foundation may wish to re-evaluate progress made and opportunities presented after 2016. At the moment, for example, the Foundation is investing in European capacity for putting biofuel and biomass usage trajectories on sustainable pathways toward 2030.

Several other risks, and appropriate risk mitigation measures, include the following:

- ***Repeal of the RFS2 in its entirety.*** There is considerable consensus that the removal of RFS2 support for advanced and cellulosic biofuels would essentially "orphan" these second-generation fuels from an investment-capital perspective. The pathway to commercial viability for these fuels becomes almost prohibitively difficult vis-à-vis the incumbent position of corn ethanol without a continued policy or market signal about the desirability of these fuels—either specific supports for the development of truly low-carbon fuels or a carbon tax of some sort on high-carbon fuels. Apart from maintaining public education efforts regarding the importance of the advanced/cellulosic categories of the RFS, the other risk mitigation measure would be to support military-civil collaboration on the development and use of advanced aviation biofuels.

- ***Failure of the RSB to capture significant market share for certified biofuels*.** The Roundtable on Sustainable Biomaterials has been successful in articulating a high-road set of sustainability standards for use in the biofuels industry. It has been less successful persuading key stakeholders to commit to rigorous GHG mitigation standards for its certified products. The Packard Foundation has worked with RSB leadership on funding and commercial development plans so as to protect its existing investment in this entity, and it has worked to keep GHG mitigation questions on the table for RSB members.

- ***Revisions to the European Union's overall renewable energy use targets in response to changing understanding of the GHG and food security impacts of biofuel and biomass use.*** We support the EU's pursuit of a cap on the use of food-based first-generation biofuels and encourage continued EU inquiry into the GHG mitigation performance of biomass at different use volumes. Assisting with this critical analysis, and expanding public education regarding the importance of a policy capping use of first-generation fuels, is meant to deepen support for the EU's climate policies and to sharpen the policy responses that will bring the Renewable Energy Directive into better alignment with EU climate policies. Support for critical analysis is not intended to provide ammunition to the arguments of "climate-change deniers" or those who seek to weaken the EU's important commitment to GHG mitigation. Our partners in Europe are mindful of this issue and have developed strategies to prevent misappropriation of their work.

MONITORING AND EVALUATION

Policy changes sought, and changes to the types and volumes of biofuel and biomass usage, are suggested as part of the Outcomes and Objectives noted earlier in Table 1. Table 2 suggests specific targets for each of the nine Outcomes.

In 2016, the Foundation may retain an independent expert to help compile information on progress toward targets; to interview practitioners, scientists, NGOs, policy makers and business leaders; and to provide a written review of our grantmaking and achievements.

The Packard Foundation invites comments and critical analysis of this strategy document and looks forward to receiving feedback.

TABLE 2. Specific Targets for Nine Outcomes

	Outcomes	Measured by…	Monitored via…	Grantee involvement
1	Prevent further expansion of U.S. corn ethanol	Reform of the RFS2 to eliminate privileges for corn	Legislative reform enabled through public education.	Public education Communications Interaction with EPA
2	Ensure no incentives for palm-oil-based biofuels	EPA denial of petition for advanced fuel status	Evidence of meetings with EPA EPA citing/ using scientific findings prepared by grantees	Relationships with EPA Communications Preparation of scientific opinion re palm oil's ILUC impacts
3	New EU biofuel standards adopted by member-states	Adoption of better standards in EU-27	Campaign materials + meetings with policy makers	National-level campaigning Advocacy work in Brussels
4	RSB bioenergy standards help to establish global sustainability norms	Expanded use of RSB as a certification body	Expansion expressed as: – product volumes – # of certifications	Support to RSB # of RSB mentions in pro-advanced biofuels campaign materials
5	Establishment of safeguards so that outbound bioenergy investments by United States and Brazil meets strict sustainability standards	BNDES adoption of safeguards U.S. OPIC/EXIM commits not to provide support for food-based biofuel projects Sustainability criteria adopted in countries that have bioenergy use mandates	Campaign materials targeting Brazilian government (esp. BNDES) and industry, using GHG, food security, and land-rights arguments	Campaign development for Brazil and investor-destination countries Greater clarity on use of food security arguments
6	Improvements in GHG and land-use (ILUC) accounting clarifies sustainability trade-offs of bioenergy use	New scientific information from IPCC and other sources impacts the development of volumetric use targets	Findings in IPCC 5th Assessment re bioenergy are widely discussed Sustainability-oriented scientists become more prominent in bionenergy debates	Interactions between policy analysts and scientists Development of an informal network of scientists and policy analysts to review new findings

Table 2. Specific Targets for Nine Outcomes (continued)

	Outcomes	Measured by…	Monitored via…	Grantee involvement
7	Sustainability criteria introduced into national debates on ethanol and biofuel use mandates	Adoption of sustainability criteria as part of new national biofuel use mandates Modification of existing mandates to reflect improved sustainability science	Feedback from target countries Country-specific research aggregated and used by international bodies (FAO, CFS, WB etc)	Active in debates on mandates in target countries Development of simple materials in appropriate languages to improve understanding of ILUC
8	U.S. biogenic carbon rules accurately account for net GHG emissions, over the same timeframes referenced in other emission reduction goals	EPA final rule	Evidence of meetings and technical exchanges with EPA staff Development of campaign materials	Interactions with EPA Public education
9	EU modifies biomass use targets to reflect sustainability criteria	Absolute cap on Europe's global sourcing of biomass, and/or promulgation of a mandatory 50 percent reduction in GHG emissions from biomass	Evidence of meetings and technical exchanges with Euro Commission staff Development of campaign materials	Interactions with Brussels-based and prominent national-agency scientists, as well as with scientists in the United States Public education

APPENDIX I.

Three parameters must be considered in developing a projection of future transport-sector greenhouse gas (GHG) emissions, and the mitigation potential of biofuel use, at country or global levels:

- **Volume of total liquid fuel used in a given year**. The global trend is upward, based particularly on demand in Asia. U.S. gasoline usage has declined over the last five years of recession and recovery; it is unclear whether the decline represents a long-term shift in consumption patterns, or how fuel-price-sensitive this trend is.
- **Percent met from biofuels, broken out by volume of feedstock**. Many national mandates call for gradual increases in the amount of ethanol blended into national fuel supplies, or mandate increased use of biodiesel. The current U.S. States Renewable Fuel Standard (RFS2) breaks out its mandate using several different categories of feedstock and assigns lifecycle GHG emission reduction results to them. In its Low Carbon Fuel Standard (LCFS), California set carbon-intensity reference values based on the type of fuel used. Brazil adjusted its biofuel "mandatory minimum" blending requirement to 20 percent in 2011, with virtually all of that coming from sugarcane ethanol. The European Union (EU) is in the process of approving regulations that would cap use of food-based feedstocks in its liquid fuel supply at 6 or 7 percent (after 2020), without predetermining what feedstocks will replace corn ethanol and various biodiesels.
- The **net GHG savings associated with each feedstock** compared with a fossil fuel (petroleum) equivalent. This is by far the most contentious parameter, particularly the inclusion or non-inclusion of indirect land use change (ILUC) and the assumptions that accompany those calculations. The newest GREET model (version 2.7), which informs U.S. policy, argues that relative to petroleum gasoline, ethanol from corn, sugarcane, corn stover, switchgrass, and miscanthus can reduce life-cycle GHG emissions by 19–48 percent, 40–62 percent, 90–103 percent, 77–97 percent, and 101–115 percent, respectively. Using California's carbon intensity plus ILUC numbers, by contrast, corn ethanol from the Midwest would lead to net increases in GHG emissions compared with fossil fuel use in California, while Brazilian sugarcane ethanol comes in at a 23 percent reduction overall and is thus eligible for use under the LCFS. California sets cellulosic ethanol at an 80 percent GHG reduction compared with fossil fuels equivalent; federal RFS2 numbers are even more optimistic for cellulosic ethanol from corn stover or switchgrass. Other researchers reject the GREET numbers out of hand, suggesting that none of first-generation feedstocks, including sugarcane, result in actual emission reductions because of routine, systematic undercounting of indirect land use changes.

Deriving a target GHG reduction number from these variables is obviously complicated. A ballpark estimate of *global* mitigation potential would take into account:

- Suggested estimates of the global liquid fuel market in 2020, 2030, and 2050 (timeframes frequently used in studies of renewable energy usage in the global economy).
- The adoption of ethanol blending targets by 50 countries that represent well over half of total global liquid fuel demand—adding GHG increases from ethanol use but subtracting out the displacement of fossil fuels.

- Inclusion of biodiesel targets (especially palm oil and soy) in national liquid fuel supplies.
- The ability of cellulosic and other non-food biofuel feedstocks with substantially better GHG emission reduction profiles to compete in existing ethanol markets.
- Market differentiation of biofuels, via certification and national policy requirements, based on the adoption of sustainability parameters that include net GHG emissions compared with fossil fuels.

A frequently cited 2012 study[45] suggests a total global biofuels (bioethanol plus biodiesel) market of 135 billion gallons by 2018, based mostly on double-digit growth in Asia and rapid increases in biodiesel use. A rough estimate suggests that half of this use is displacing fossil fuels through blending, while the other half represents an absolute increase in liquid fuel use. The 135 billion gallons correspond roughly to 35 percent corn ethanol, 35 percent sugar ethanol, 20 percent biodiesel, and 10 percent advanced biofuels. These feedstocks in turn have very different GHG profiles, and the numbers are still highly disputed. Still, we used the following rough GHG life-cycle emission improvements for corn (0 percent—no improvement),[46] sugar (50 percent reduction in GHG emissions),[47] biodiesel (0 percent—although the +/- variations based on different biodiesel feedstocks are large),[48] and cellulosic (80 percent reduction)[49] to extrapolate a rough estimate of fossil fuel emissions equivalent saved. The savings correspond to the removal of 34.5 billion gallons of fossil gasoline from the global liquid fuel supply annually in 2018, accounting for 253M tons of CO_2 mitigation—equivalent to removing 52 million passenger vehicles from the roads, using the U.S. miles-traveled standard. Improvements in that number would depend on shifts overall toward more sustainable feedstocks and improvements in field- and conversion-efficiency performance of individual feedstocks.

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45 Global Industry Analysts, "Biofuels (Bioethanol and Biodiesel) – A Global Strategic Business Report." See http://www.strategyr.com/Biofuels_Bioethanol_Biodiesel_Market_Report.asp#RCC.
46 Number based on California's lifecycle assessment.
47 Number based on the GREET model.
48 We considered a range of values, from +20 to –20 percent. Ideally, this parameter could be further broken out by individual feedstock, since rapeseed/canola, soy, and palm show such different GHG profiles. In the end, we settled on a "zero" figure for all biodiesels.
49 Number based on California's lifecycle assessment.

APPENDIX 2

Table 3 below shows the projected biofuel and bioenergy use from different feedstocks and the key sustainability concerns associated with each. This allows us to focus in on those cells that are of particular importance to the subprogram strategy—with green cells coded for positive impact and red cells indicating negative trends that the strategy seeks to counter. Yellow cells indicate where we have lower confidence in our numbers, which are thus areas where additional science is particularly needed.

A range of data sources were consulted in constructing this Table. For volumes and expected increases by 2020 (and beyond), we used International Energy Agency studies and studies by the Food and Agriculture Organization and the Organisation for Economic Co-operation and Development. For GHG emission reductions as compared with a fossil fuel equivalent, we reviewed numbers from the U.S. Environmental Protection Agency (2010), the California Air Resources Board (2009), Searchinger et al. (2008), Tyner et al. (2011), and GREET model outputs and FAPRI data. An important "meta-study" by Stephanie Searle and Chris Malins at the International Coalition for Clean Transportation (ICCT) attempted to refit the data from these studies according to a single counting methodology, based on the ICCT's best estimates, for better comparability (yields, available land, animal feeding models, baseline food production, etc.).

Indirect land use change is by far the most contentious parameter, with ILUC estimates at the high end suggesting that very few biofuel feedstocks lead to significant GHG reductions, while low-end numbers suggest that most feedstocks lead to better GHG outcomes than fossil fuel equivalents. Adopting one or the other of these two extremes would clearly affect the overall strategy by impacting the distribution of green and red cells in the model. Instead we have presented two columns providing different measures of GHG impact and mitigation potential. GHG Impact 1 uses stated values for feedstocks from models and published work that undergird policy choices in the European Union, in California, and at the U.S. federal level. GHG Impact 2 purports to represent "best available science," specifically through repurposing data released in mid-2013 by the Joint Research Centre of the European Commission.

Finally, these models are constructed to reflect the GHG emission changes associated with use of a feedstock and do not model for possible impacts on food prices based on acreage being committed to bioenergy. Here again estimates vary widely, and a qualitative judgment is used to highlight particularly adverse impacts with respect to food security.

Table 3. Projected Biofuel and Bioenergy Use

Table **Feedstock**	**Use of feedstock by 2021[a]**	**Feedstock ramp-up potential to 2035[b]**	**GHG Impact (1)[c]**	**GHG Impact (2)[d]**	**Deforestation and land use impact**	**Food security + other impacts**	**Comments**
Corn	25 B gal	Low-Medium	Zero to –20%	+20% to +40%	Medium-High	High	U.S. consumpt = 22B of the total
Sugar	16 B gal	Medium-High	–50%	–50%	Medium	Medium	Brazil consumpt = 12B of total
Other food-based ethanol	7 B gal	Low-Medium	Zero to –20%	Zero to –20%	Medium	Medium	Mostly wheat in Europe; MTBE still an allowed oxygenate in EU
Soy (biodiesel)	10 B gal for all biodiesel	Low-Medium	–50%	+50%	Medium	Medium	Palm oil is cheaper than alternatives but a less effective feedstock; palm oil likely to substitute other products, with more vegetable oils coming into biodiesel use
Palm (biodiesel)		High	+50%	+100%	Very high	High	
Other vegetable oils for biodiesel		Medium	Zero to –30%	+50%	Medium	Medium	
Woody biomass from whole trees	>1 B gal	High	+30% to –30%?	+100% to +200%	High	Medium	Limited biofuel use could expand rapidly if technical challenges solved
Energy Crops	>1 B gal	Very High	–80%	?	Medium-High	Medium	Mostly cellulosic ethanol, but also energy crops used in heat + power sectors
Wastes and Residues	2 B gal?	Low	–90%	–90%	Low	Low	Corn stover + animal fats each ~1B gal by 2020?

a. Numbers drawn from the FAO/OECD Agricultural Outlook 2012-2021 (thus the use of the year 2021 for this column). See http://stats.oecd.org/Index.aspx?QueryId=36348.

b. Judgment call by authors based on literature review and conversations with experts.

c. Numbers are composite of US-EPA and California LCFS estimates; the unit used is "GHG emissions compared with fossil fuel equivalent," with reductions showing up as negative numbers and positive numbers indicating a net increase in emissions. These numbers show modeling of individual feedstocks, rather than a "cumulative impact assessment," which may drive GHG improvement numbers down with increased utilization.

d. Numbers are rough composites of European Union Joint Research Centre model comparison exercise numbers, using conservative estimates of 40tC/ha for land use change and modest peat emissions. Corn numbers are based on JRC and Plevin (2010).