BIOFUELS: OPPORTUNITY OR THREAT?

A BACKGROUND BRIEFING

Depending on how biofuels are developed and which energy sources are used to manufacture them, growth in this area could bring environmental, economic, and community benefits or it could place many systems, including freshwater ecosystems, at significant risk.

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EXECUTIVE SUMMARY

For the first time in 60 years, the carbohydrate economy is back on the public-policy agenda. We may be changing the very material foundation of industrial economies. Whether and how we effect that change can profoundly affect the future of our natural environment, our rural economies, agriculture, and world trade. It is an exciting historical opportunity, but one we should approach with deliberation and foresight.

—David Morris, *The Once and Future Carbohydrate Economy*, April 2006

Situated at the intersection of water, energy, and agriculture issues in the Midwest is the rapidly growing field of biofuels. Interest in biofuels has surged along with the call for independence from Middle East oil. Depending on how biofuels are developed and which energy sources are used to manufacture them, growth in this area could bring environmental, economic, and community benefits—or it could place many systems, including freshwater ecosystems, at significant risk.

Government policies, private-sector investment, and research priorities are already influencing the development of biofuel industries, and foundations are beginning to identify ways to foster this new energy industry in sustainable ways.

In November 2006, the Environmental Grantmakers Association, in partnership with the Sustainable Agriculture and Food Systems Funders, hosted a two-day, Midwest Regional Policy Briefing to explore these themes as they relate to the development of liquid transportation fuels. This publication was prepared for distribution at the event. In addition to the detailed discussion of biofuels presented below, a matrix (page 5) is included to assist readers in identifying related intersections of funder interest. Pages 12–18 include a list of resources for funders interested in biofuels and the related fields of sustainable agriculture, water use, habitat preservation, climate change, and energy; a summary of foundation grantmaking around biofuels; and a glossary of terms used in this report. We hope grantmakers will appreciate the interconnectedness of these issues and develop strategies to leverage funding opportunities for more sustainable fuel production.

What Are Biofuels?

A biofuel is a liquid form of energy derived from recently harvested organic material, either vegetation (such as prairie grasses and corn kernels and stalks) or animal byproducts (such as livestock or poultry manure). Biofuels include biologically produced alcohols (ethanol, methanol, butanol); gases (biogas); and oils for use in diesel engines.

Biofuels are particularly attractive because they are currently the only renewable source of liquid transportation fuel. Although biomass can be and is used to generate electricity, the recent enthusiasm for biofuels development has been generated by its potential use as a liquid fuel to displace imported oil in the transportation sector, the primary focus of this report.

A BRIEF HISTORY OF BIOFUELS IN THE UNITED STATES

Rudolf Diesel originally designed his eponymous 1893 engine to run on peanut oil, and Henry Ford's first Model T ran on ethanol. Both inventors envisioned a transportation future built not on petroleum but on biofuels. In 1925, when Ford told a *New York Times* reporter that ethyl alcohol was "the fuel of the future," he was expressing an opinion widely shared in the automotive industry. However, through most of the 20th century, the price per gallon of domestic oil remained roughly one-third lower than that of ethanol, undercutting development of a mass domestic alcohol-fuel industry.

American farmers embraced the vision of new markets for farm products, especially alcohol fuel, three times in the 20th century: around 1906, again in the 1930s with Ford's blesssing, and more recently during the oil crisis of the 1970s. By the mid-1980s, more than one hundred corn-alcohol production plants had been built, and more than a billion gallons a year of ethyl alcohol were sold. But in the late 1980s and early 1990s, with the oil glut seemingly permanent and fuel prices at rock bottom, most of these alcohol plants were shut down. Some observers joked that ethyl alcohol was indeed "the fuel of the future"—and always would be. "Gasohol" had become passé.[1]

Nevertheless, with the assistance of a 52-cent-per-gallon federal subsidy in place since 1973, ethanol remained a bit player in Midwest fuel markets, poised to enter a volatile energy market when oil prices rose again.

The Recent Biofuels Boom

Liquid biofuels made from grains and vegetable oils—corn ethanol, cellulosic ethanol, and biodiesel—now supply about 2 percent of the nation's light-duty vehicle fuel.[2]

Corn Ethanol

Ethanol's ability to replace the polluting chemical MTBE as a fuel oxygenate led to the resurgence of ethanol use in the late 1990s, with production doubling between 1998 and 2003. Rapidly rising oil prices spurred further interest in advanced biofuels.

Even the most optimistic supporters acknowledge that corn's use for ethanol fuel production will likely be limited to about 15-20 billion gallons per year (or around 10% of U.S. gasoline demand) before it impinges upon other uses of the grain.

In 2005, the United States produced and consumed about four billion gallons of ethanol. Adjusting for its lower energy content, that represents only about 2 percent of U.S. gasoline demand. But by late 2006, U.S. production capacity had grown to 5.01 billion gallons per year, with capacity for another 3.04 billion gallons per year under construction (see Figure 1).[3] Now, as we near the apparent peak of world oil supplies, some are predicting a return to a predominantly biomass-fueled economy (see Figure 2).[4]

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Figure 1

U.S. Ethanol Fuel Production, *millions gallons*

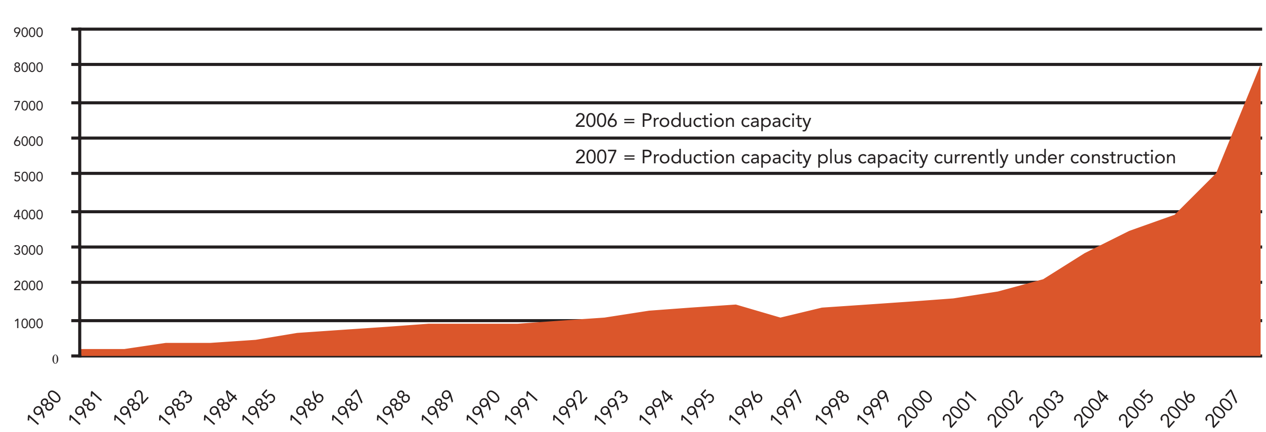
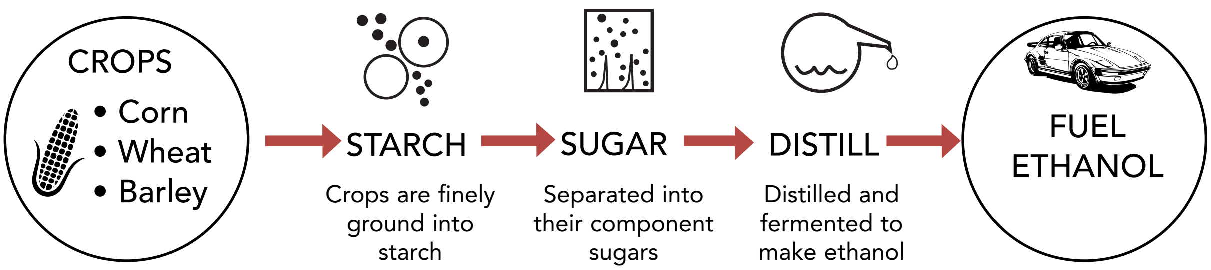


Figure 2

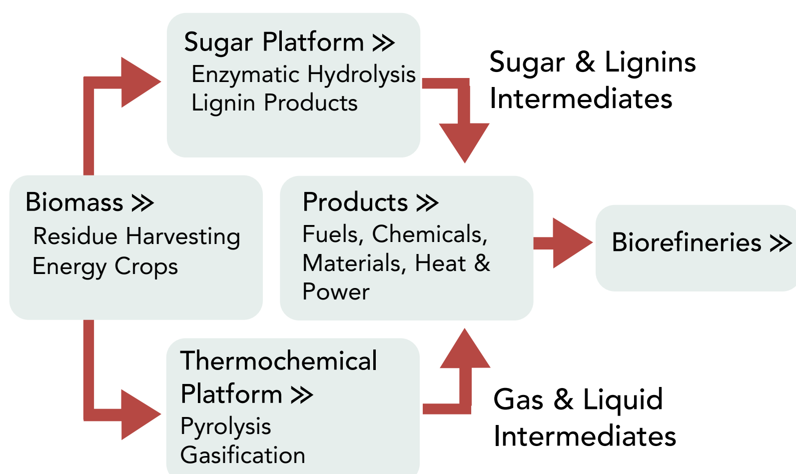
How to Make Biofuels

Making **ethanol** today is like making moonshine, although on a much larger scale—a typical production facility might produce 50 to 100 million gallons of ethanol a year. The corn used for ethanol production is field corn typically used to feed livestock, not the sweet corn marketed for human consumption. Ethanol production also results in byproducts—mainly distillers dried grains (DDGs)—which can be used to feed livestock.



Source: Environmental and Energy Study Institute

Making advanced **cellulosic ethanol** from the tough fibrous materials in the stalks and leaves of plants is more complicated and expensive. The process involves using steam or acid baths to separate lignocellulose into lignin, a chemical compound that gives strength to the plants, and cellulose or hemicellulose, where energy is stored. Special enzymes can then convert the cellulose into sugars that can be brewed into ethanol. Alternatively, heat and pressure can be used to break down cellulose into gases (gasification) or oils (pyrolysis).



Source: U.S. Department of Energy, Energy Efficiency and Renewable Energy Biomass Program

Biodiesel: The Recipe (Source: Environmental and Energy Study Institute)

Making biodiesel is relatively simple: a fat or oil is reacted with an alcohol (e.g. methanol) in the presence of a catalyst, and in the process biodiesel and glycerine are produced.

- 1 molecule soybean oil
- 3 molecules methanol
- A dash of alkaline catalyst
- Yields 3 molecules of biodiesel and 1 of glycerine

continued from page 2

However, more than 90 percent of the ethanol currently produced in the U.S. is derived from corn. While substantial productivity and conversion gains are still being achieved with corn ethanol, the ultimate potential of cornstarch ethanol is limited. Even the most optimistic supporters acknowledge that corn's use for ethanol fuel will likely be limited to about 15-20 billion gallons per year (or around 10 percent of U.S. gasoline demand) before it impinges upon other uses of the grain. [5]

The World Energy Council and World Energy Assessment project that bioenergy could supply perhaps a quarter of global energy demand by 2050 (250 to 450 exajoules/year).

Cellulosic Ethanol

The real potential for biofuels production lies in using cellulose—the hard, fibrous material found in all plants—rather than the more readily useable starch. Ethanol derived from cellulose is believed to be able to generate eight to ten times more energy than the fossil fuel used to produce it, and has the potential to produce between 30 and 60 billion gallons of fuel each year (between 15 percent and 30 percent of current gasoline demand). Cellulosic ethanol also promises a solution to many of the ecological challenges of corn ethanol, permitting the use of native local vegetation in multi-cropping systems that provide habitat, reduce erosion and runoff, sequester carbon in soils, and require less water and fewer chemical inputs.

However, cellulose by its very nature is more difficult to break down and therefore must be converted into fermentable sugars before it can be transformed into energy. Two different conversion methods are available to convert cellulosic ethanol: heat or thermal processes (gasification or pyrolysis) and biochemical processes (using bacteria or enzymes). The enzymes needed to break down cellulose have been genetically modified from natural organisms, such as the fungus that caused the "jungle rot" that ate through clothing in the South Pacific during World War II and the enzymes found in the gut of termites, which convert woody biomass to sugars.

Biodiesel

Biodiesel is a diesel fuel derived from plant oils. The most common U.S. source of plant oils is soybeans, while European producers tend to use canola (rapeseed). Palm from equatorial regions is another potentially large source of oil. Biodiesel can also be made from corn oil, waste cooking grease, and the oil of other crops.

Although biodiesel production in the United States is still very small scale, even compared with ethanol production, it has expanded rapidly in recent years. While just 500,000 gallons were produced in 1999, in 2006 that figure rose to an estimated 150 to 250 million gallons, more than double the 75 million gallons of biodiesel produced in 2005 and six to ten times the 25 million gallons produced in 2004. These recent figures still represent only 0.125 percent of the U.S. diesel market and less than 10 percent of the one billion gallons produced in Europe.[6]

Estimates of biodiesel's production potential remain sketchy. The U.S. Department of Energy estimates that 415 million gallons could be produced from soybeans.[7] But experiments at producing biodiesel from algae suggest that the potential yield could be much higher. One National Renewable Energy Lab study projected that the entire U.S. transportation fuel demand could be met by algae reactors sited on 15,000 square miles of desert, an area that represents only about 12.5% of the Sonoran Desert, for example.[8] Because it requires significantly less energy to produce than ethanol or gasoline, and results in lower greenhouse gas emissions, biodiesel is likely to remain an important part of the transportation fuel sector.

IMPLICATIONS OF BIOFUELS

Whatever feedstock is used, large-scale biofuels development will have far-reaching impacts. As shown in Figure 3 (see page 5) and discussed in this report, biofuels development can be either very beneficial or very destructive to most or all of the key issue areas noted. How can we ensure we get it right?

Energy

The World Energy Council and World Energy Assessment project that bioenergy could supply perhaps a quarter of global energy demand by 2050 (250 to 450 exajoules/year). In Brazil, roughly 80 percent of all cars

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Figure 3

Biofuels development could profoundly impact all of these key issue areas.

	Potential outcomes, by sector	Results will depend on:
Energy, Transportation	OPPORTUNITY Reduced reliance on foreign energy Advanced automotive technology THREAT Reduced efficiency incentives	Do investment priorities reflect appropriate mix of renewable energy sources & efficiency gains?
Climate Change	OPPORTUNITY Reduced greenhouse gas emissions THREAT Neutral or even increased GHG emissions	Transition to cellulosic ethanol will reduce GHG emissions. Corn ethanol is more ambiguous.
Sustainable Agriculture	OPPORTUNITY Increased use of native plant crops THREAT Displaced food crops COULD GO EITHER WAY Soil erosion Use of genetically modified organisms	Crop choice will be driven by whether conversion technologies embrace diversity of crops or remain monoculture-focused.
Water & Air	OPPORTUNITY or THREAT Criteria air pollutants Water demand Chemical (fertilizer & pesticide) inputs and pollution	Crop choices and practices. Use of more corn will increase soil erosion, chemical inputs, and polluted runoff. Lower level ethanol blends increase some air pollutants.
Biodiversity & Habitat	OPPORTUNITY Increased crop diversity & wildlife habitat THREAT Pressure to plow wildlife habitat and marginal, erosive lands (including Conservation Reserve Program lands)	Crop choices and management practices. Use of native plants can provide habitat. How is highest use of biomass determined?
Rural Economies	OPPORTUNITY Investment opportunities for farmers Income from energy crops THREAT Continued or increased concentration of ownership	Linking incentives to ownership and production size Access to capital; initial cost of cellulosics favors large investors.
Global Impacts	OPPORTUNITY or THREAT Food security in developing countries Tropical habitat destruction	Higher prices for corn could reduce pressure on farmers in developing nations. Higher prices for biodiesel oil crops encourage destruction of tropical rainforests.

Environmental Grantmakers Association 2006

Figure 4

Estimated Energy Benefits of Biofuels

Fuel Source	Energy Balance
Ethanol – corn	4% to 50% energy gain, average gain estimated at 23% to 25%.
Cellulosic Ethanol	Estimates of 800%-1000% energy gain.
Biodiesel	220% energy gain (USDOE/USDA data)
Gasoline	19.5% loss (USDOE/USDA data)
Diesel	15.7% loss (USDOE/USDA data)

continued from page 4

can run on ethanol and 40 percent of all auto fuel is domestically produced ethanol derived from sugar cane.

In the United States, the Department of Energy envisions a sustainable supply of biofuels sufficient to displace 30 percent or more of the country's current petroleum consumption. If vehicle fuel efficiency were doubled during the same period, that figure could arguably rise to 75 percent by 2030. This transition would require approximately 1 billion tons of biomass feedstock annually, or a seven-fold increase in the biomass currently consumed for bioenergy and bio-based products. To reach that goal, in turn, requires several advances, including a 50-percent increase in corn and wheat yields; recovering 75 percent of crop residues (where sustainable) and the use of all other available residues; no-till cropping; and 55 million acres dedicated to the production of perennial bioenergy crops.[9]

Although still subject to debate, most recent studies agree that the energy produced by corn ethanol exceeds the fossil energy needed to make it. How *much* additional energy is produced depends on assumptions regarding the corn yield per acre; the energy consumed in corn production, including fertilization, cultivation, and harvest; the energy efficiency of the conversion process; and the energy balance of any byproducts. In cases where renewable resources are used in processing ethanol-such as in Brazil, where sugar cane waste is used to heat boilers-ethanol contains as much as eight times more energy than is used to produce it. Recent studies indicate an average energy gain of 23 percent to 25 percent from corn ethanol. Both cellulosic ethanol and biodiesel are estimated to provide even greater energy yields.[10]

One thing is clear: Corn ethanol's fossil energy balance is much greater than that of other end-use energy forms, as noted in Figure 4. More than 70 percent of the energy used to make electricity from coal is lost in the process of bringing power to homes in a usable form. Ethanol typically consumes 77 units of fossil energy to deliver 100 units of fuel energy, whereas oil requires 120 units for each 100 units of fuel energy. Converting all natural energy forms into commercial end-use energy forms involves losses. What makes a positive energy balance possible is that renewable energy inputs like sunshine are not typically counted as energy inputs. Thus, if cellulosic ethanol were made from perennials that do not require annual planting and intensive fertilizer application, it would offer an even greater positive energy balance than corn ethanol.

Figure 5

Fuel Source	Criteria Air Emissions
Ethanol – corn	Low-level blends of ethanol have been shown to increase ground level ozone pollution. Blends of about 45% and higher do not have this problem and some studies show it is possible to create low-level blends that do not increase ozone pollution. Recent studies indicate this may not be true.
Cellulosic Ethanol	Same as corn ethanol.
Biodiesel	13% increase in nitrogen oxides in pure biodiesel; 3% increase for B20.

Transportation

About one-third of the gasoline sold in America today contains some ethanol.[11] Most of it is E10, a blend of 90 percent gasoline and 10 percent ethanol that can be used in any car.

- More than six million flex-fuel vehicles capable of using ethanol blends of up to 85 percent (E85) are already on the road, although many car owners do not use ethanol fuel regularly. U.S. automakers recently pledged to roll out another two million flex-fuel vehicles annually by 2010. Automakers receive credits against the federal Corporate Average Fuel Economy (CAFE) standards for producing these vehicles, which some observers believe undermines incentives to improve vehicle efficiency. Ramping up widespread distribution channels for ethanol remains a hurdle to mass utilization of flex-fuel vehicles.

More than 250 major fleets use biodiesel blends, including military, state and city fleets. However, sulfur content has limited the ability of diesel-powered cars to meet federal and state emission standards in the United States. The recent introduction of low-sulfur diesel fuel (which represents just 3 percent of older fuel) and of a new generation of diesel engines could eliminate that problem. Several engine and automobile manufacturers have signaled that more high-mileage diesel-fueled cars, a fixture on European highways, may become available.[12]

Air Quality

All ethanol fuel blends reduce levels of dangerous pollutants such as cancer-causing benzene as well as carbon monoxide. Ethanol blends also reduce soot particulate matter (PM) pollution by up to 36 percent. New Environmental Protection Agency, California Air Resources Board, and other state air-quality monitoring data demonstrate that ozone exceedance days dropped after ethanol use increased in several states, contradicting previous EPA and CARB studies that showed increased ozone formation associated with the use of low-level ethanol blends.[13] Overall, using higher-blend biofuels should make it easier to reach air-pollution-reduction targets than using petroleum-based fuels or smaller amounts of ethanol in blended fuels (see Figure 5, previous page).[14]

Climate Change

- The extent to which corn ethanol reduces greenhouse gas emissions compared with fossil fuels depends on several factors, including inputs, processing, and distribution. Biodiesel provides greater emissions reductions and cellulosic ethanol is predicted to generate significantly fewer emissions (see Figure 6). A key issue today is the transition from natural gas to coal energy at ethanol refineries in the United States: of the two energy sources, coal releases substantially more carbon per unit of energy.

Recent research by the Natural Resources Defense Council and University of California, Berkeley indicates that the life-cycle carbon emissions from biofuels range widely, depending on production techniques. In the worst case, where ethanol is made with corn grown with substantial fertilizer inputs and with annual tillage, then converted using coal as a heat input, its life-cycle carbon emissions can actually be *worse* than those of gasoline. In the best case, however, where corn is grown more sustainably and converted in an ethanol refinery using biomass heat inputs, carbon emissions can be almost as low as those predicted for cellulosic ethanol. If these production methods are combined with carbon capture and storage, ethanol's carbon emissions can actually be negative.[15]

Sustainable Agriculture

- Which crops are grown where, and under which cultivation methods, will determine whether the biofuels industry is sustainable or harmful to the environment. Lessons from industrialized agriculture point to a

Figure 6

Fuel Source	Greenhouse Gas Emissions
Ethanol – corn	Estimates range from 14%–46% reduction per gallon, compared to gasoline
Cellulosic Ethanol	Estimates as high as 100% reduction
Biodiesel	70%-80%

need to avoid crop monoculture as well as to reduce pesticide and fertilizer inputs, prevent soil erosion, curtail water use, and minimize downstream impacts. In light of these concerns, corn has drawbacks that make massive expansion of corn-based ethanol problematic. For example, it requires heavy applications of herbicides and pesticides, which pollute surface water, as well as copious amounts of nitrogen fertilizer, which is made largely from natural gas. A significant expansion of corn production would cause farmers to use land only marginally suitable for this crop, such as slopes, buffers, and land committed to the Conservation Reserve Program. This practice could increase erosion and runoff (see Figure 7). Finally, it may encourage farmers to grow corn every year, rather than in a more sustainable rotation with soybeans and other crops.

At the other extreme, ethanol production can help restore a facsimile of native habitats by, for example, using perennial grasses grown in polyculture combinations as a feedstock for cellulosic ethanol. Such grasses also build soil, reduce erosion, use water more efficiently, and sequester carbon.

Water and Soil Quality

- A significant expansion of corn crops to meet ethanol demand would likely increase the amount of chemical fertilizer, soil erosion, and water pollution in the Upper Midwest and downstream. Ethanol production from corn kernels is already booming in this region. Each year from 1998-2002, the region sent nearly $400 million worth of excess fertilizer down the Mississippi River.[16] That amount is poised to increase significantly with the planting of multiple years of corn back-to-back (without nitrogen-restoring rotations of soybeans planted in between).

In contrast, using native crops to produce cellulosic ethanol under appropriate planting and harvesting management could benefit water quality. However, farmers are eyeing corn stalks ("stover") on their land as the next profit center once conversion technologies for cellulosic ethanol are commercially available. Widespread removal of cornstalks would undermine decades of soil conservationists' admonitions to leave corn stubble in the field to reduce soil erosion-and would reduce the long-term productivity of the landscape.

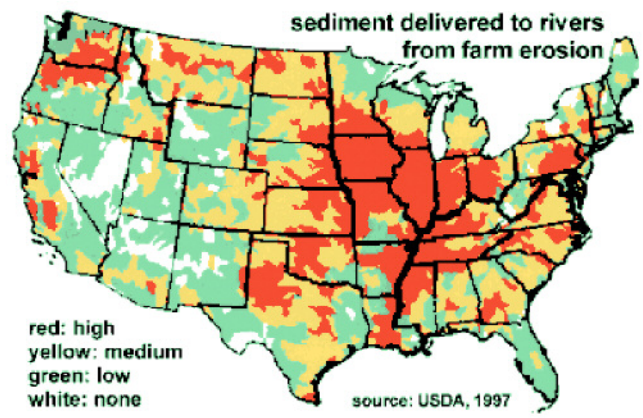

Figure 7. The red regions on the map above show where erosion from U.S. farm fields results in the highest quantities of sediment entering rivers and streams. Such areas include the states leading the nation in production of corn-based ethanol. (Source: USDA[17].)

Biodiversity and Habitat

Massive expansion of corn ethanol production could encourage the plowing under of millions of acres of native grasses or other wildlife habitat. In contrast, making the leap to cellulosic ethanol could encourage increased use of native plants, particularly switchgrass and mixtures of prairie grasses in the Midwest.

- The extent to which increased use of native feedstocks will deliver habitat benefits will, in turn, depend on factors such as harvesting practices (timing harvests around wildlife needs), whether monoculture plantings or a diversity of crops are used, and whether planting biofuels crops displaces existing habitat.

In some cases, efforts to further boost crop yields and develop new feedstocks are being addressed through genetic engineering, with all its attendant controversies. The risks of genetic drift, in which genetically engineered properties spread to natural plants, have not been studied. A further threat is the introduction of non-native species that could become invasive pests.

Rural Economies

Farmer and local-resident-owned biorefineries hold out the possibility of reinvigorating local economies by providing economic opportunity to beleaguered family farmers. Calibrating production incentives such that the economic benefits stay in communities will be critical to capturing that opportunity.

Biofuels production can create local benefits in the form of jobs, tax payments, and increased prices for crops. One study found that an average-sized ethanol plant (producing 40 million gallons per year) can support the creation of as many as 694 new permanent jobs, generate at least $1.2 million in new tax revenues for state and local governments, and increase corn income by about five to 10 cents per bushel.[18]

"Full-scale cellulosic processing plants might cost up to three times as much as a comparable corn-ethanol refinery, a price that favors Wall Street investors over farmers."

Locally owned refineries may offer even greater benefits to communities. While the ethanol industry was launched initially by large corn-processing companies such as Archer Daniels Midland (ADM), a boom in farmer-owned ethanol refineries in the 1990s, driven especially by policies in Minnesota and Iowa, gave farmers a significant financial stake in the ethanol industry. Outside investors, however, have begun to displace these local owners. A number of farmer-owned plants are opting to sell out now to take advantage of the huge investor interest in ethanol, and to avoid competing against much larger, privately owned plants. Other farmer-owned plants are rapidly expanding to meet this challenge.

In 2003, some 50 percent of all ethanol refineries and perhaps 80 percent of all proposed plants were majority owned by farmers. The average new plant produced about 40 million gallons of fuel per year. Today, about 80 percent of new ethanol production occurs at absentee-owned plants that produce 100 million to 125 million gallons per year.[19] Just one in eight ethanol plants under construction this summer was farmer-owned, compared with eight in 10 just two years ago, according to the Renewable Fuels Association.[20]

- Access to capital and production incentives that favor local ownership will make a difference in whether biofuels increase or reduce concentration of ownership in the agricultural sector. As Doug Tiffany, a University of Minnesota production economist and ethanol researcher, has pointed out, "Full-scale cellulosic processing plants might cost up to three times as much as a comparable corn-ethanol refinery, a price that favors Wall Street investors over farmers." [21]

Thus, it is likely that the first movers in advanced biofuels will be large companies as well, given the high economic risk, large capital demands, and technical expertise required. Iogen Corporation, for example, has formidable financial backing from Shell and Goldman Sachs, and is likely to pursue government policies that reduce financial risk (such as loan guarantees or startup subsidies). Under these circumstances, it is hard to say when the smaller players will be able to make the leap to cellulosic feedstocks. A number of farmer-owned refineries have announced plans to use cellulosic materials, such as the CORN-er Stone Farmers Co-op in Luverne, Minnesota, but whether they can take the risk will depend on how rapidly the conversion technologies become commercially viable.

The move to cellulosic feedstocks could also expand the range of biofuels production outside the Midwest and beyond traditional crops. This change could make biofuels production an economic development option for many more rural areas, as well as urban areas using urban waste streams.

Global Impacts

Global fuel ethanol production more than doubled between 2000 and 2005, while production of biodiesel, admittedly starting from a much smaller base, expanded nearly fourfold. The potential for biofuels production is particularly large in tropical countries, where high crop yields and lower costs for land and labor-which dominate the cost of these fuels-provide an economic advantage that is hard for countries in temperate regions to match. In fact, biofuels promise to bring a much broader group of countries into the liquid fuel business.[22]

In contrast, many of the countries that consume large quantities of transportation fuels, including the United States, have limited land available for planting biomass feedstock, which leaves them unable to produce much more than a fraction of their transportation fuels from domestic biomass. This dilemma will likely encourage many industrial countries to consider importing biofuels and to push for elimination of tariffs and other trade barriers that have so far limited biofuels trade. Ongoing negotiations at the World Trade Organization aimed at liberalizing trade in agricultural commodities are likely to spur the move to freer trade in biofuels, offering an opportunity for countries to generate new agricultural revenues. [23] As with domestic production, the distribution of benefits will depend on local policies and incentives designed to encourage small producers and local processing.

- The potential domestic (U.S.) impacts of biofuels are mirrored on a global scale, but would be played out in a context of even greater political and economic imbalances. Increased demand for internationally traded bioenergy crops could displace food crops, increase water use, and encourage habitat destruction. Expanding European biodiesel demand, for example, is already driving international trade in vegetable oil feedstocks, particularly imported tropical feedstocks with higher energy content than any of the vegetable oils grown in temperate countries. Indonesia is reportedly cutting down rainforest in order to grow vegetable oil crops to meet this demand. To combat this trend, European observers are seeking to link trade to standards that would prohibit the purchase of biofuels produced at the expense of habitat.

FINANCING BIOFUELS

In 2005, global wind and solar markets reached $11.8 billion and $11.2 billion, respectively–up 47 percent and 55 percent, respectively, from a year earlier. The market for biofuels hit $15.7 billion globally in 2005, up more than 15 percent from the previous year. According to Clean Edge research, biofuels (the global manufacturing and wholesale pricing of ethanol and biodiesel) will grow from a $15.7 billion industry in 2005 to a $52.5 billion industry by 2015. [24]

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Oil companies are partnering with–or buying stakes in–manufacturers and distributors of ethanol and biodiesel to make biofuels more widely available. Since 2000, Royal Dutch Shell has invested $1 billion in alternative energy, including buying into the Ottawa-based biotechnology firm Iogen to make cellulosic ethanol from straw. Chevron expects to spend as much as $25 million over five years to fund research into next-generation biofuels at UC-Davis and the University of Georgia. And BP Amoco recently announced it will invest $500 million toward a university research facility (not yet selected) to develop potential bio-renewable fuel solutions.

ADM has traditionally dominated ethanol production, once controlling more than 60 percent of the industry. It remains the country's leading refiner, having produced approximately one billion gallons in 2006, but now controls just under 25 percent following the building of a number of farmer-owned ethanol plants in recent years. The company plans to recapture some market share by adding 550 million gallons of ethanol capacity over the next two years. [25]

Venture capitalists are also taking note of these trends, many of them motivated by the dual goals of making money and addressing climate change. Richard Branson, CEO of the Virgin Group, for example, announced that over the next decade he would put $3 billion towards the development of energy sources that do not contribute to global warming. Silicon Valley-based Khosla Ventures is working with former President Bill Clinton on a $1 billion fund that will invest in renewable energy research. And Microsoft co-founder Bill Gates, through his investment company, put $84 million into Fresno, California-based Pacific Ethanol.

The first major Wall Street investment in biofuels came this year when Goldman Sachs & Company took a $28 million minority share in Iogen. In the Midwest, Iowa has seen more than $2.5 billion invested in renewable fuels plants over the last five years. Iowa's premier venture capitalist, John Pappajohn, is working to raise an estimated $800 million from Wall Street to create an Iowa-based company, Renewable Energy Plus, that would acquire up to 10 existing farmer-owned ethanol plants.[26]

Please refer to pages 14–16 for information about the philanthropic sector's current commitments to biofuels and related issues.

BIOFUELS POLICY DIRECTIONS [27]

In addition to private sector investment, government policies and investments are, and have been, influencing the direction of biofuels development.

Production Incentives

The most significant U.S. federal policy driver for ethanol has been the provision of tax incentives. For the last 25 years, ethanol manufacturers have benefited from the Volumetric Ethanol Excise Tax Credit (VEETC), a tax exemption of 52 cents for every gallon of ethanol they produced. The exemption was reduced to 51 cents per gallon in 2004 and is expected to continue to decline. An additional tax credit of 10 cents per gallon goes to plants that produce fewer than 60 million gallons a year.

Production incentives for cellulosic biofuels are embedded in the 2005 Energy Policy Act, Section 942, which authorizes $250 million for "reverse auction" incentives to reach one billion gallons of cellulosic biofuels production by 2015. The Department of Energy has requested comments on how to implement this program, but an appropriation level has not yet been determined for FY07.

Renewable Fuels Standards

The Energy Policy Act requires that 7.5 billion gallons of renewable fuels (defined as ethanol, biodiesel, and cellulosic ethanol) be utilized by 2012. One gallon of cellulosic ethanol or waste-derived ethanol will be counted as 2.5 gallons through 2012. The standard also mandates the use of 250 million gallons of cellulosic ethanol per year after 2012. Based on the number of additional refining facilities already under construction, the industry is likely to reach the 7.5 billion gallon goal years ahead of schedule.

Key future policy questions for the renewable fuels standards (RFS) include:

- Should the RFS be increased? Members of Congress have introduced legislation to increase the current mandate dramatically. Some versions (H.R. 4357 and S. 3553) would move up the deadline from 2012 to 2010, and increase the portion of renewable fuels required from 7.5 billion gallons to 10 percent of all fuels.
- Should there be defined goals within the standard for cellulosic ethanol and biodiesel?

Research and Development

The Research and Development Policy Act of 2000 was most recently re-authorized in the 2005 Energy Policy Act. The program, which encourages the development of cost-effective ways to produce more energy from biomass, particularly cellulosic ethanol, provides $14 million per year in mandatory spending. Another $200 million in discretionary spending has been authorized for FY07. Important provisions of the act include:

- Sec. 945, Regional Bioeconomy Development Grants, competitive grants for coordination, education, and outreach to support and promote growth of a bio-economy, are authorized at $1 million for 2006 and at "such sums as necessary" for FY07-15. The Senate FY07 appropriation level is $3 million.
- Sec. 946, Processing and Harvesting Demonstration Grants, competitive grants for the purpose of demonstrating cost-effective cellulosic biomass innovations. A budget of $5 million per year has been authorized for FY06-10.
- Sec 947, Education and Outreach, which authorized $1 million per year for education and outreach on bio-based fuels and products for FY06-10.

Integrated Biorefinery Demonstration Projects

Section 932(d) of the 2005 Energy Policy Act is designed to help prove that cellulosic ethanol is viable on a commercial scale. The Department of Energy is currently reviewing solicitations from nearly 30 applicants seeking assistance to build commercial-scale cellulosic ethanol plants. If funds are appropriated, $100 million will be distributed to three of them in FY07, but the current appropriation is for only $50 million. Another $125 million and $150 million have been authorized for this program in 2008 and 2009, respectively.

Loan Guarantee Program for New Technologies

Title XVII of the 2005 Energy Policy Act provides for up to $2 billion in loan guarantees to eligible projects that encourage early commercial technologies that will avoid, reduce, or sequester air pollutants and employ new or significantly improved energy technologies. Biofuels production, distribution, and infrastructure projects all are eligible. The deadline for this program was re-extended through December 31, 2006, meaning applicants are still awaiting notification of their awards.

Upcoming Legislation

Currently 570 pieces of legislation related to energy are pending in the Senate and 700 in the House. Among the 30-odd bills that include further incentives for ethanol, several require automakers to build more cars that can burn the 85 percent ethanol blend, rather than the 10 percent blend sold today. The issue of local control is also on the agenda, specifically as a part of H.R. 5372, the Bioenergy Innovation, Optional Fuel Utilization, and Energy Legacy (BIOFUEL) Act of 2006.

State-Level Biofuel Use and Distribution Incentives

Many states provide biomass incentives, such as renewable fuel standards and mandates for state fleet use of biofuels, to create market demand and/or to help new biofuels producers get established.

Several states have enacted requirements that all, or the majority of, gasoline sold in that state contain E10, a transportation fuel that contains 10 percent ethanol. Nearly a decade ago, Minnesota was the first in the nation to pass an E10 requirement. (It was also the first state to require the use of biodiesel blends for all diesel-powered vehicles.) Montana, Hawaii, Iowa, Missouri and Washington also have passed renewable fuel standards.[28] New York passed a residential bioheat credit that provides tax incentives for biodiesel blended into home heating oil. The Louisiana legislature has passed renewable fuels standards, and in Colorado the legislature passed a renewables standard subsequently vetoed by the governor. In several states, the standard does not kick in until a production threshold has been met.

In California, Proposition 87 would establish a $4 billion program, funded by a tax on oil extracted from California wells, to reduce oil and gasoline use by 25 percent over the next decade. The proceeds would be spent on California ventures encouraging clean-energy alternatives. The measure's requirement that the funds be spent on near-term solutions, capable of reaching the market in five to seven years, would favor biofuels such as ethanol over hydrogen-cell technology, the viability of which many believe is farther off. The measure also establishes a board to distribute the money among universities, research facilities, and private firms to promote development of alternative fuels and to encourage the use of alternative-fuel vehicles by businesses, transportation agencies, and consumers. Nearly 60 percent of the funds would go toward incentives to buy alternative-fuel vehicles and for private entities to build alternative fueling stations.

BIOFUELS RESOURCES

PUBLISHED MATERIALS

Overviews

"After Oil" (*The American Prospect*, April, 2006). A special issue on biofuels, with multiple essays covering a range of issues. http://www.prospect.org/web/page.ww?section=root&name=Green+Economy

Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century (Worldwatch Institute and the German Agencies for Technical cooperation and Renewable Resources, June 2006). An assessment of opportunities and risks associated with large-scale international development of biofuels. http://www.worldwatch.org/taxonomy/term/445 (site requires registration; an extended summary is currently available online).

"Ethanol: The Facts, the Questions. The Industry is Booming, but Where is it Headed Next?" (*Des Moines Register*, August 27, 2006). A good series on ethanol. http://desmoinesregister.com/apps/pbcs.dll/article?AID=/20060827/OPINION03/608250397/1035/OPINION

Roadmap for Agriculture Biomass Feedstock in the United States (National Renewable Energy Lab, November 2003). An assessment of what it would take to achieve a supply of 1 billion dry tons of biomass fuel feedstocks (current use is 20 million dry tons). http://devafdc.nrel.gov/pdfs/8245.pdf

Energy Balance

"The Carbohydrate Economy, Biofuels and the Net Energy Debate," David Morris, Institute for Local Self Reliance, August 2005. http://www.newrules.org/agri/netenergyresponse.pdf

"Ethanol Can Contribute to Energy and Environmental Goals," Farell, Plevin, Turner, Jones, O'Hare, & Kammen, *Science Magazine*, January 2006. The paper and the model used are available on the UC-Berkeley website: http://rael.berkeley.edu/ebamm/

"Ethanol Fuels: Energy Balance, Economic and Environmental Impacts Are Negative," in *Natural Resources Research*, David Pimentel, Cornell University. June 2003. http://www.newrules.org/agri/netenergyresponse.pdf

"The 2001 Net Energy Balance of Corn-Ethanol," USDA. Update to original study, published June 2004, with responses to Pimentel et al.'s critiques. http://www.usda.gov/oce/reports/energy/net_energy_balance.pdf

INFORMATION PORTALS

Biofuels Legislation Fact Sheets. A series of fact sheets and presentation notes from the Environment and Energy Study Institute that covers the latest in federal policy developments. http://www.eesi.org/publications/Fact%20Sheets/factsheets.htm

Carbohydrate Economy Clearinghouse. A source of current articles, studies, and commentary on a wide range of issues related to biofuels from the Institute for Local Self Reliance. http://www.carbohydrateeconomy.org/

Ethanol: Energy Well Spent, A Survey of Studies Published Since 1990 (February 2006). A literature review of existing research on ethanol production, commissioned jointly by the Natural Resources Defense Council and Climate Solutions. http://www.nrdc.org/air/transportation/ethanol/ethanol.asp

Governors Ethanol Coalition. Numerous ethanol fact sheets and publications, including the coalition's own well-designed briefing book. http://www.ethanol-gec.org/pub.htm

Renewable Fuels Association. Up-to-date information about the ethanol industry, including plant locations, capacity, and ownership. http://www.ethanolrfa.org/

GOVERNMENT RESOURCES

U.S. Department of Agriculture Reports on Renewable Energy. http://www.usda.gov/oce/reports/energy/index.htm

U.S. Department of Energy's Energy Efficiency and Renewable Energy, Biomass Program. http://www1.eere.energy.gov/biomass/

Bioenergy Feedstock Information Network (BFIN). A gateway to biomass feedstock information resources from the U.S. Department of Energy, Oak Ridge National Laboratory, Idaho National Laboratory, National Renewable Energy Laboratory, and other research organizations. http://bioenergy.ornl.gov/main.aspx

STATE-SPECIFIC RESOURCES

The Minnesota Project. Includes clean-energy fact sheets and a case study assessing the results of a biogas digester installed on a Minnesota dairy farm. http://www.mnproject.org/pub-energy.html

CONFERENCE PROCEEDINGS

Growing the Bioeconomy (annual conference, Iowa State University, August 28-29, 2006). A good source for quick overviews of the latest thinking, as well as academics and private sector organizations working in this area. http://www.bioeconomyconference.org/default.html

Agriculture as Producer and Consumer of Energy (sponsored by the Farm Foundation, June 2004). Includes a list of research and data needs identified by participants. It also includes links to papers commissioned by and a book produced by the conference. http://www.farmfoundation.org/projects/documents/FF_EnergyExecfortheWEB_000.pdf

Symposium on Sustainable Feedstocks for Biofuels Production (sponsored by the Energy Foundation and McKnight Foundation, March 2006). Focuses on sustainable agriculture: production, harvesting, and feedstock selections. The website includes the conference proceedings, highlights, and background materials. http://www.ef.org/subsite_biofuels.cfm

Foundations Directly Funding Biofuels

Foundation	Funding Strategy	Funding Amount	Program Officer
Bullitt Foundation www.bullitt.org Seattle, WA	The Bullitt Foundation has a program focusing on Energy and Climate Change. It promotes solar, wind, biomass, and geothermal energy development at appropriate locations and with minimal environmental impact. It intervenes in regulatory processes on behalf of green electricity options, renewable portfolio standards, system benefits charges, net metering, and least-cost energy planning. Its geographic focus is on Washington, Oregon, Idaho, western Montana, coastal Alaska, and British Columbia.	No information.	Amy Solomon, program officer
Energy Foundation San Francisco, CA www.ef.org	The Energy Foundation is a partnership of major donors interested in solving the world's energy problems. Its mission is to advance energy efficiency and renewable energy utilizing new technologies that are essential components of a clean energy future.	About $1.2 million in biofuels in 2005 and 2006.	Ben Paulos, program officer
McKnight Foundation Minneapolis, MN www.mcknight.org	The goal of McKnight grantmaking is that Upper Midwest will provide a significant portion of the nation's renewable energy supply for electricity and transportation fuels.	Funding for advanced biofuels began in 2005: $10 million over 5 years. Since 1997, its renewable energy grantmaking has been in partnership with the Energy Foundation.	Gretchen Bonfert, program director
Rockefeller Brothers Fund www.rbf.org New York, NY	Rockefeller Brothers' program areas are Sustainable Development and Combating Global Warming. The fund supports advocacy to accelerate biofuels development as a means to combat global warming. An additional focus is on democratic practice to ensure that this transition is made in a sustainable and transparent way.	Sustainable development accounted for 70% of RBF 2005 grantmaking, or nearly $15.8 million. Over the next two years RBF will invest roughly $500,000 in biofuels work. Average grant size in sustainable development is about $63,000.	Jessica Bailey, program officer
Turner Foundation www.turnerfoundation.org Atlanta, GA	The Turner Foundation provides funding for advocacy and policy work to advance energy efficiency and renewable energy. Geographic priorities include Georgia, Florida, South Carolina, Montana, and New Mexico, as well as some nationwide programs.	$800,000 for energy and climate, including about $250,000 for biofuels. $500,000 for air quality (much of this work relates to energy)	Judy Adler, program officer
United Nations Foundation / Better World Fund www.unfoundation.org Washington, DC	The United Nations Foundation and its sister organization, the Better World Fund, support the Energy Future Coalition to promote leadership on climate change and U.S. domestic energy policy. The Energy Future Coalition is a broad-based, nonpartisan alliance that seeks to bridge the differences among business, labor, and environmental leaders and to identify energy policy options with broad political support.	The UN Foundation will provide about $2 million to the Energy Future Coalition (EFC) in 2006. The UNF and the EFC will each spend an addition $1 million on energy and climate, for a combined total of about $4 million. UNF is spending about $750,000 on international biofuels development. About $250,000 of EFC's work is focused directly on biofuels, with much of the rest of the budget indirectly supporting biofuels as one of the leading renewable alternatives.	Reid Detchon, Executive director, Energy and Climate

Foundations Engaged in Funding Related Work

Foundation	Funding Strategy	Funding Amount	Program Officer
The David and Lucille Packard Foundation www.packard.org Los Altos, CA	The Packard Foundation's China Sustainable Energy Program supports China's efforts to increase energy efficiency and use of renewable energy. The U.S. Clean Energy Program supports domestic efforts to address climate change at the state level. The Energy Foundation manages all grant inquiries for the foundation in these two program areas.	For 2006, Packard allocated $5 million for the China program and $2 million for the U.S. Clean Energy Program.	
Emily Hall Tremaine Foundation www.tremainefoundation.org Meriden, CT	The Emily Hall Tremaine Foundation supports efforts in the Northeast that focus on developing and promoting climate change solutions. The goal for the Climate Change Initiative is to pioneer strategies for addressing global warming at a state level and to empower Connecticut and other Northeast states to be integral partners in state- level and regional campaigns that spur federal action.	Emily Hall Tremaine provided $795,000 to seven climate- change projects in 2005. Average grant size was just over $100,000.	Nicole Chevalier, program officer
George Gund Foundation www.gundfdn.org Cleveland, OH	George Gund's related program areas are Green Buildings and Sustainable Energy. The Foundation seeks to advance approaches to reduced energy consumption and waste. Its funding is in Ohio, particularly Northeast Ohio. Gund does not have an explicit biofuels program, although it does make operating grants to some state policy groups (e.g.., Ohio Environmental Council) whose programs sometimes touch on biofuels.	George Gund Foundation appropriated two grants in the environment program in 2006, for a total of $160,000 over two years. The average award was $80,000 over two years.	Jon Jensen, program officer
Great Lakes Protection Fund www.glpf.org Evanston, IL	The interest of the Great Lakes Protection Fund is to assure that water issues related to the ecological health of the Great Lakes basin remain in the foreground of any transition to biofuel cropping, transportation, and refining. The foundation is paying attention to biofuels as it touches on existing work in ecological health.	Returned $1.6 million to member states in 2005 and paid $2.8 million for regional projects. It lists 26 active projects in 2005.	David Rankin, program director
The Joyce Foundation www.joycefdn.org Chicago, IL	The Joyce Foundation's focus is on energy from clean coal. It committed $7 million over three years (2005-2007) to ensure that the next generation of Midwest coal plants use state-of-the-art technology to minimize climate change and pollution.	Total given to environment was just over $6.2 million for 37 projects in 2005. The average grant size was $168,000, with a range of $42,000 to $787,000.	Margaret O'Dell, senior program officer
Nathan Cummings Foundation www.nathancummings.org New York, NY	Nathan Cummings has a related program area in Environment & Contemplative Practice. The foundation seeks to foster sustainability and environmental justice by supporting the accountability of corporations, governments, and other institutions for their environmental practices. In energy, support has focused on the Apollo Project's national, regional, and statewide projects to spark action and policy development in renewable energy and efficiency.	Annual support to Apollo Project energy work this year was about $400,000 for national work, and about $250,000 for regional efforts, for a total of close to $750,000 per year.	Peter Teague, program director or James McClelland, program assistant

Foundation	Funding Strategy	Funding Amount	Program Officer
Oak Foundation www.oakfdn.org Portland, ME	The Oak Foundation works on climate-change issues in North America and Europe. In North America it works specifically in the Northeast and occasionally on U.S. federal policy. Areas of interest are the electricity sector and transportation. The foundation supports advocacy and policy development at the national, state and local levels; works with the private sector and industry to reduce greenhouse gas emissions and increase energy efficiency; and supports diverse constituencies like the faith community. The foundation also supports NGOs who work with the investment community to shift funding away from dirty energy and into clean energy.	Oak Foundation does not provide any grants specifically to biofuels.	Leslie Harroun, senior program officer, environment
Surdna www.surdna.org New York, NY	Surdna is currently revising program guidelines, to be ready early 2007. The foundation anticipates continued funding in the climate change energy nexus, although it will not be directly funding biofuels.	Surdna invested $7.78 million in environmental grantmaking in 2005.	Hooper Brooks, program director
Wallace Global Fund www.wgf.org Washington, DC	Related program objectives include strengthening efforts to reduce greenhouse gas emissions; promoting environmentally sound renewable energy sources versus fossil fuels and nuclear power; shifting investment flows; and harnessing consumer pressure.	Provided $130,000 to three renewable energy and energy efficiency projects in 2005, and a total of $636,000 to another 14 projects that address climate change. Provided a total of $1.3 million to natural resources projects in 2005. Average grant size was $55,000.	Amy Salzman, senior program officer
William & Flora Hewlett Foundation Menlo Park, CA www.hewlett.org	The goal of the William and Flora Hewlett Foundation is to reduce the environmental impacts of fossil-fuel energy systems by promoting energy efficiency and renewable energy sources. Its three-part strategy includes promotion of a new, visionary, and bipartisan approach to national energy policy; building a clean electric energy system in the western United States; and encouraging cleaner, more energy-efficient cars and trucks—and systems—in key cities and countries.	$8 million was given to the Energy Foundation and $275,000 to the Governor's Ethanol Coalition in 2005. Total environment funding was just over $39 million in 2005. Average grant size was just over $300,000, ranging from $5,000 to $2.4 million.	Hal Harvey, program director

GLOSSARY

Advanced biofuels. "Advanced biofuels" refers to cellulosic ethanol-ethanol fuels made from the cellulose in plants using thermal pressure or biochemical processes (see text and graphic of Figure 2, *How to Make Biofuels*).

Bio-based products. Whereas petroleum and coal are made from biological/organic plant and animal material compressed for eons under bedrock, bio-based products are made from biological/organic plant material and animal byproducts recently harvested. In theory, anything that can be made from petroleum can be made from biomass. A biorefinery could use biomass to produce fuel as well as plastics, solvents, adhesives, and drugs.

Biofuel. Fuel made from biomass, i.e., organic material with stored chemical energy. Agricultural products specifically grown for use as biofuels include corn and soybeans, flaxseed, rapeseed, and hemp. Two main types of biofuels are used as transportation fuels: Bioethanol, which is alcohol derived from sugar or starch from, for example, sugar beet, cane, or corn, and biodiesel, which is derived from vegetable oils such as rapeseed, jatropha, soy, or palm oil.

Biodiesel. An oxygenated fuel made from vegetable oils, animal fats, or recycled fats. Biodiesel can be used as a full replacement for diesel fuel (B100), but it is most commonly found mixed at a ratio of 20 percent biodiesel to 80 percent regular diesel (B20). At very low blends of 1 to 2 percent, it greatly improves the lubricity of low-sulfur diesel. Biodiesel is produced in pure form (B100), but in the United States is usually blended with petrodiesel at low levels, usually between 2 percent (B2) to 20 percent (B20). In other parts of the world, particularly in Europe, higher-level blends of up to 100 percent are used. Biodiesel in any blend can be used in diesel engines with few to no modifications, although using higher percentages of biodiesel in cold temperatures can cause engine ignition problems.

Bio-butanol. An alcohol with a four-carbon structure and the molecular formula $C_4H_{10}O$. It is used primarily as a solvent, an intermediate in chemical synthesis, and as a fuel. Like ethanol, bio-butanol is produced through the fermentation of biomass. The fermentation process for butanol uses the bacterium *Clostridium acetobutylicum*, also known as the Weizmann organism. Chaim Weizmann first used this bacterium in 1916 to produce acetone from starch (acetone's main use is in the production of Cordite). Butanol was a byproduct of this fermentation (twice as much butanol as acetonewas produced).

Exajoules. A joule is one watt of power for one second. An exajoule is 10 to the 18th power joules. Current estimates calculate world demand for energy in one year to be 428 exajoules. An estimated 4 percent of those 428 exajoules are now satisfied by clean, renewable energy sources.

Ethanol. A grain alcohol produced by fermenting and distilling starch crops that have been converted into simple sugars. The 200-proof ethanol is mixed with an distasteful substance, called denaturant, to prevent people from drinking what is essentially pure alcohol. Coproducts, including high-protein animal feeds, are developed in the process of fermentation and distillation. Ethanol is typically used in blends with conventional gasoline at blends of 10 percent (E10), 85 percent (E85), and 95 percent (E95). These blends achieve the same octane boosting (or anti-knock) effects as petroleum-derived aromatics such as benzine or metallic additives such as tetraethyl lead. Blends of 20 percent or more typically require minor fuel tank modifications such as those found in "flex-fuel vehicles (FFVs)."

Cellulosic ethanol. Another form of ethanol produced using either heating technology (gasification) or biochemical-conversion technology involving enzymes and bacteria that transforms the hard, fibrous content of plants-cellulose and lignin-into starches that can be fermented by other bacteria to produce ethanol. Cellulosic ethanol utilizes cellulose found in the stems and leaves of plants and items manufactured from plant materials. It can be derived from fast-growing energy crops such as willow trees and switchgrass, or from waste products such as sugar cane bagasse, rice hulls, orchard prunings, wheat straw, forest thinnings, municipal wastes such as waste paper and yard wastes, and industrial wastes such as pulp/paper and sludge. As with starch-based ethanol, cellulosic ethanol can be blended with gasoline or used as a pure fuel. Though cellulosic ethanol is not yet commercially viable, researchers hope to reach that point within the next five years.

Methanol (methyl alcohol). Alcohol fermented from wood that, unlike ethyl alcohol, is poisonous to humans.

Net energy balance (also: energy balance). The difference between the energy needed to produce a fuel and the energy the fuel contains.

Oxygenate. Oxygenated substances have been infused with oxygen. The term usually refers to oxygenated fuels. Oxygenates are typically added to fuels to reduce carbon monoxide that is created during burning. Some oxygenates, such as MTBE, have been found to contaminate groundwater, mostly through leaks in underground gasoline storage tanks. In 2004, California and New York banned MTBE, generally replacing it with ethanol. Several other states switched soon afterward. The requirement to add oxygenates to fuel was recently repealed as part of the federal Renewable Fuels Standard.

Transesterification. In organic chemistry, transesterification is the process of exchanging the alkoxy group of an ester compound with another alcohol. These reactions are often catalyzed by the addition of an acid or a base. In energy production, transesterification is the process through which biodiesel (alkyl esters) is made from vegetable oils and/or animal fats.

ENDNOTES

1. Bill Kovarik, "Henry Ford, Charles F. Kettering and the Fuel of the Future," *Automotive History Review*, Spring 1998. http://www.radford.edu/~wkovarik/papers/fuel.html
2. Environmental and Energy Study Institute, "Sustainable Energy Factoid #8," Renewable Energy and Energy Efficiency Fact Sheets. http://www.eesi.org/programs/energyandclimate/EEREFactSheetsIndex.html
3. Renewable Fuels Association, http://www.ethanolrfa.org/industry/locations
4. David Morris, "The Once and Future Carbohydrate Economy," *The American Prospect*, April 2006.
5. National Corn Growers Association, "How Much Ethanol Can Come from Corn?" http://www.ncga.com/ethanol/pdfs/2006/HowMuchEthanolCan%20ComeFromCorn.v.2.pdf
6. Susan Moran, "Biofuels Come of Age as the Demand Rises," *The New York Times*, September 12, 2006. http://www.nytimes.com/2006/09/12/business/smallbusiness/12bio.html
7. U.S. Department of Energy and U.S. Department of Agriculture, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, April 2005.
8. National Renewable Energy Lab, *Biodiesel from Aquatic Species*: *Project Report*, 1993.
9. U.S. Department of Energy and U.S. Department of Agriculture, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, April 2005.
10. Although most studies find a net energy gain from corn ethanol, David Pimentel of Cornell University has published multiple studies indicating a negative energy balance. See the Biofuels Resources for links to his and other studies examining the energy balance question.
11. "...nearly all RFG, which makes up about one-third of U.S. gasoline consumed, contains ethanol." U.S. Energy Information Administration, "This Week in Petroleum," May 10, 2006. http://tonto.eia.doe.gov/oog/info/twip/twiparch/060510/twipprint.html
12. Felicity Barringer, "Low-Sulfur Diesel Fuel Is Reaching Market," *The New York Times*, October 11, 2006.
13. Renewable E Action Project, "Cleaning the Air with Ethanol," March 2006.
14. Natural Resources Defense Council, "Unlocking the Promise of Ethanol: Promoting Ethanol While Protecting Air Quality," February 2006. http://www.nrdc.org/air/transportation/biofuels/contents.asp
15. B. Paulos and J. Kleinschmit, "The Promise of Biofuels: A New Harvest for America, the Environment and Rural Communities," *EGA News*, Fall 2006.
16. Environmental Working Group, *Dead in the Water: Reforming Wasteful Farm Subsidies Can Restore Gulf Fisheries*, 2006. http://www.ewg.org/reports/deadzone/
17. Marc Ribaudo, U.S. Department of Agriculture Economic Research Service. This image accessed October 25, 2006 at http://www.ers.usda.gov/briefing/ConservationAndEnvironment/Gallery/sediment.htm; page last updated December 2000.
18. John Urbanchuk, AUS Consultants and Jeff Kapell, SJH & Company, "Ethanol and the Local Community," June 2002. http://www.ethanolrfa.org/objects/pdf/outlook/outlook_2004.pdf
19. David Morris, Institute for Local Self Reliance, "The New Ethanol Future Demands a New Public Policy," June 21, 2006. http://www.ilsr.org/columns/2006/062106.html
20. Star Tribune Staff, "Outside Interests Put Money on the Table," *Minneapolis Star Tribune*, October 3, 2006.
21. Ibid.
22. Worldwatch Institute & German Federal Ministry of Agriculture, "Biofuels for Transportation, Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century," June 2006.

23. Ibid.

24. Joel Makower, Ron Pernick, and Clint Wilder, "Clean Energy Trends 2006," *Clean Edge Reports*, March 2006. http://www.cleanedge.com/reports-trends2006.php

25. Bloomberg News Service, "Profit Rises at A.D.M.," *New York Times*, November 1, 2006.

26. Elbert David, "Pappajohn Looks to Wall Street for $800 Million Ethanol Deal," *Des Moines Public Register*, September 24, 2006.

27. Substantial assistance for this section was provided by Jetta Wong, Environmental and Energy Study Institute.

28. National Ethanol Coalition, http://www.ethanol.org

ACKNOWLEDGMENTS

This paper was commissioned by the Environmental Grantmakers Association in partnership with the Sustainable Agriculture and Food Systems Funders as a supplement to the Midwest Funders Policy Briefing 2006: The Opportunities and Threats of Biofuels, held in Minneapolis, Minnesota.

This report would not be possible without the participation of the editorial committee members combined with the generous support of their foundations.

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The mission of EGA is to help member organizations become more effective environmental grantmakers through information sharing, collaboration and networking.

Produced by Environmental Grantmakers Association, November 2006