Union of Concerned Scientists

FACT SHEET

Turning Agricultural Residues and Manure into Bioenergy

HIGHLIGHTS

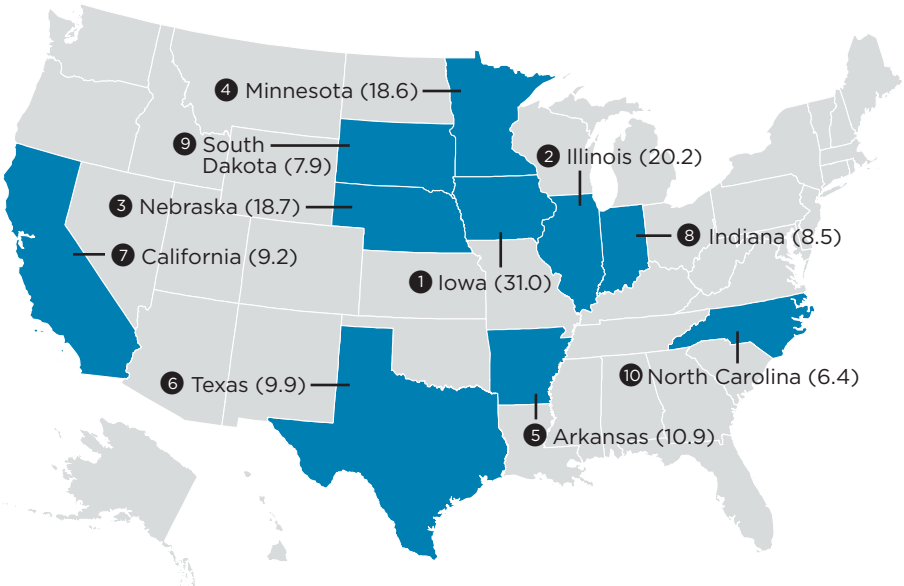
States around the country have an abundance of agricultural residues and manure, left behind from crop harvest and livestock production, that could be used to create low-carbon fuel and electricity. These biomass resources, if managed properly, can address the many challenges posed by our use of fossil fuels without competing with our food supplies. Indeed, in 2030 the United States could tap up to 155 million tons of agricultural residues and almost 60 million tons of manure for bioenergy production.

Together with boosting fuel efficiency, investing in electric vehicles, and incorporating smarter ways of doing business, sustainable biomass production is an important part of a practical, realistic plan UCS has developed to help the United States reduce projected oil use in half in 20 years. To learn more about the UCS Half the Oil plan, visit www.halftheoil.org.

Clean, renewable energy resources for transportation and electricity are an important part of the solution to the climate, economic, environmental, and security challenges posed by our fossil fuel use. Bioenergy—the use of biomass, including plant materials and manure, to produce renewable fuels for transportation and to generate electricity—can provide a sustainable, low-carbon alternative to fossil fuels while enabling communities to benefit from local resources. Bioenergy is one of several elements of a comprehensive climate strategy that can cut projected U.S. oil use in half by 2030, and help put the nation on track to phase out the use of coal in producing electricity.

The key to using biomass resources sustainably is to focus on the right ones, and to develop them in responsible ways, including at appropriate scales. To identify today's most sustainable biomass resources and scales of operation, the Union of Concerned Scientists (UCS) assessed how much biomass the United States could produce and use while carefully balancing energy and environmental tradeoffs. We found that the nation could tap nearly 680 million tons of biomass

FIGURE 1. Top 10 States as Sources of Crop Residues and Manure for Bioenergy, 2030 (Million Metric Tons)



About two-thirds of total projected U.S. crop residues and manure in 2030 will come from just 10 U.S. states.

Note: Figures expressed in million metric tons of dry biomass weight.

SOURCE: ADAPTED FROM UCS 2012.

resources each year by 2030 (UCS 2012). That's enough to produce more than 10 billion gallons of ethanol, or 166 billion kilowatt-hours of electricity—4 percent of total U.S. power consumption in 2010.

Agricultural biomass can be an important energy resource. Crop residues, in particular, are one of the largest biomass resources in the United States. The best options for using agricultural biomass and manure to produce bioenergy depend on local factors, including the type and scale of resources in each location. With the potential to tap resources around the country (see Figure 2, p. 4), the use of agricultural residues and manure to produce bioenergy offers a significant opportunity for local and regional economies.

Two Sources of Sustainable Agricultural Biomass

CROP RESIDUES

Crops such as corn, wheat, and rice consist not just of the grains we eat or feed to livestock but also of stalks, husks, cobs, and other biomass unsuitable as direct human food. These residues generally account for about half of the total biomass in U.S.-grown crops.

Historically, these materials have been used for animal bedding, burned, or left on fields. However, recent scientific advances now allow producers to turn agricultural residues into biomass-based fuels such as ethanol, or to use them to generate electricity. Overall, U.S. agriculture could provide

Agricultural residues are one of the largest potential sources of biomass in the United States.

up to 155 million tons of residues for producing bioenergy in 2030 (UCS 2012). And because they are a by-product of today's primary crops, such residues can be used to produce energy without expanding the amount of land agriculture now occupies (USDA 2009).

Residues play an important role in farming, protecting soil from erosion and loss of soil carbon, so they should be used for bioenergy only under specific circumstances, and even then, only at certain scales. How much of their crop residues farmers can sustainably remove varies from field to field, or even within a field, depending on soil conditions, the slope of the land, management practices, and the regional climate (Muth et al. 2012). Under some circumstances removing residues will cause problems (such as increased soil erosion) and under other circumstances leaving too much residues behind can prevent soils from drying in spring, and impede timely planting and other field operations.

While removing residues for use in producing bioenergy absent any other changes in agricultural practices could worsen existing environmental challenges, farmers can adapt their practices to minimize the potential harm. For example,

Agricultural residues are a natural by-product of primary crops such as corn and can be used to generate energy or fuel.

they can use no-till farming and plant cover crops to reduce soil erosion and water pollution. In so doing, they can boost agricultural productivity while expanding the amount of residues available for bioenergy even beyond our estimates (Wiggins et al. 2012).

Power plant owners can use agricultural residues to generate electricity but agricultural residues are usually not suitable for direct burning: they are processed into pellets or other forms before being used to produce power.

In corn-growing regions, large quantities of corn stover—leaves and stalks left over after corn is harvested—are available to produce ethanol (ORNL 2011). Corn residues are abundant near existing facilities fitted to produce and distribute ethanol made from corn grain. Indeed, companies are building the first three commercial-scale efforts to produce ethanol from agricultural residues near such existing facilities in Iowa and Kansas. Producing ethanol from corn grain and corn stover at the same location can reduce the use of natural gas and electricity by the combined facility, curbing the environmental footprint of the fuel.

WASTE FROM LIVESTOCK

Livestock raised in very large confined animal feeding operations (CAFOs) produce nearly unmanageable concentrations of manure, which can be used for bioenergy, but also regularly pollute water supplies in many parts of the country. Fortunately, on the smaller end of the livestock production scale, farmers can use anaerobic digesters to convert manure into biogas while reaping economic and environmental benefits. They can use the biogas to provide heat and power on the farm, or it can be further purified and sold as renewable natural gas for use elsewhere. Using anaerobic digesters to extract biogas from manure at this scale can improve water quality, reduce methane emissions from manure, and allow farmers to return nutrients to their soils.

Our analysis shows that the United States can tap almost 60 million tons of manure to produce bioenergy in 2030 (UCS 2012). This resource is best used close to where livestock produce it, and would ideally be integrated with crop production.

> ***The key to using biomass resources in a beneficial way is to focus on the right resources, and use them at an appropriate scale.***

Scientists at university research facilities, like this one at Iowa State University, are pioneering technologies to convert biomass into biofuels and other useful products.

Key States with Large Amounts of Agricultural Residues and Manure

The top 10 states (as shown in the map on p. 1) with the potential to use agricultural co-products, including crop residues and manure, to produce bioenergy include these four:

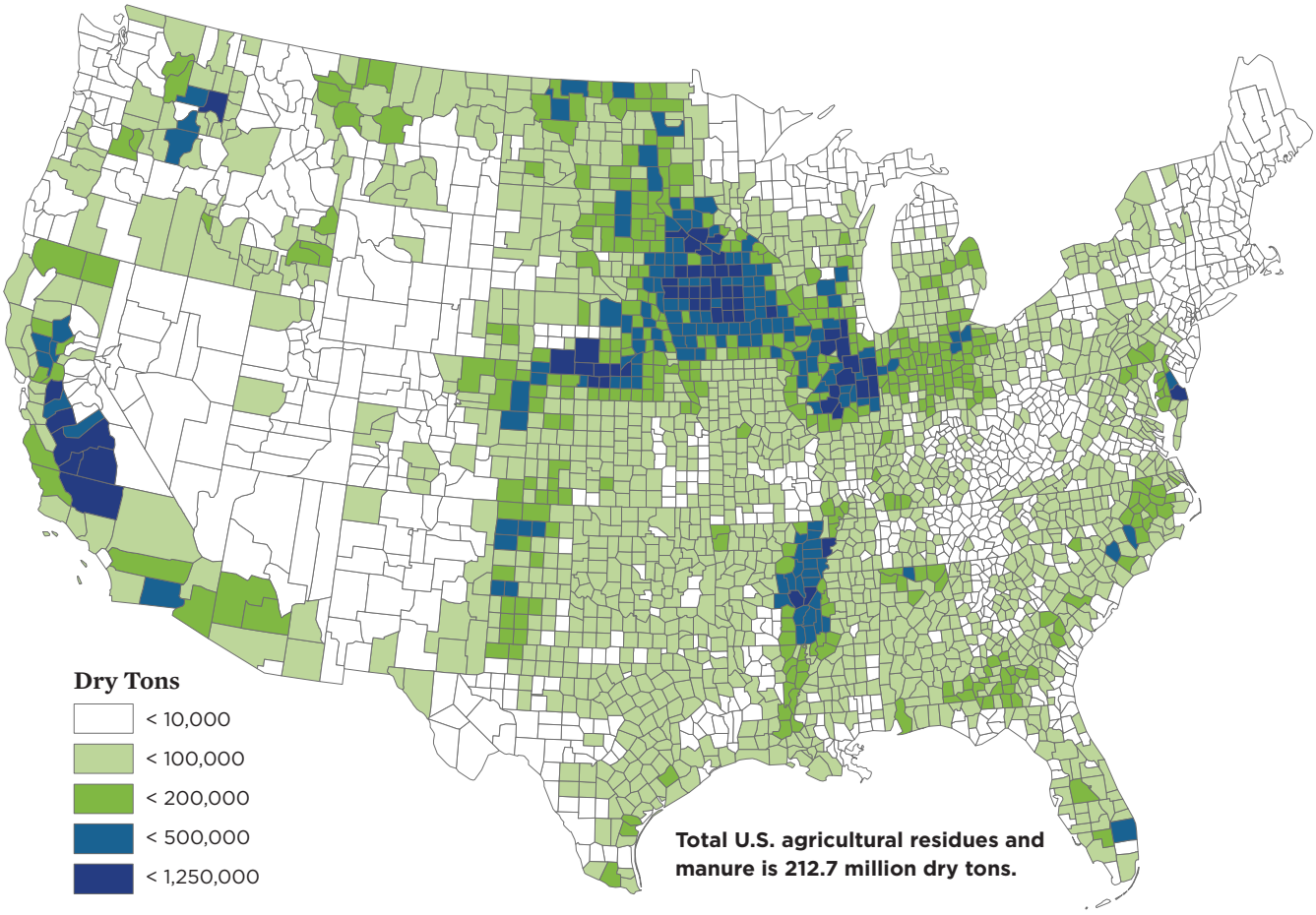
IOWA: 31 MILLION TONS

With a projected 31 million tons of agricultural residues available in 2030, Iowa has the largest potential to use such resources to produce bioenergy. The state already has extensive resources and infrastructure for producing ethanol from corn grain—and experience in doing so. Producers are building two of the first large-scale commercial refineries for using corn stover to make biofuel next to existing facilities for making ethanol from corn grain. Corn stover from Iowa farms could yield 1 billion additional gallons of ethanol each year in 2030—an expansion of more than 25 percent—without the use of one extra kernel of corn. Iowa is also the nation's leading pork producer, and the state's farmers can use the associated manure to produce biogas.

ARKANSAS: 10.3 MILLION TONS

Despite its relatively small population, Arkansas ranks first in the nation in rice production, second in poultry, and third in cotton production. This impressive agricultural output means that Arkansas farmers have substantial opportunities to provide crop residues and manure for bioenergy. Rice hulls are the largest potential feedstock for biofuel from Arkansas

FIGURE 2. Agricultural Residues and Manure Availability by County, 2030



While the most abundant agricultural residues and manure resources are located in the upper Midwest and central California, agricultural areas around the country can contribute to low-carbon bioenergy production.

Note: Agricultural residues include corn and small grains, cotton, orchard prunings, and other parts of the plant not needed for food or other uses.

SOURCE: ADAPTED FROM UCS 2012.

crops, and manure could be a significant source of biogas. Indeed, with the potential to make more than 10 million tons of agricultural residues available in 2030, Arkansas is poised to become a leader in bioenergy.

TEXAS: 9.8 MILLION TONS

One of the nation's leading agricultural states and home to a sizable cattle industry, Texas could become a major producer of bioenergy from agricultural residues and manure. Wide variations in climate across the state mean that different regions produce different amounts and types of agricultural biomass. Two significant opportunities include field residue and cotton gin by-products, together with manure from cattle. Residues from rice fields and rice hulls, and sugarcane bagasse—the material that remains after sugar production—can also provide significant biomass for bioenergy. Overall, nearly 10 million tons of agricultural co-products can be available for use in producing clean fuel and electricity in Texas in 2030.

CALIFORNIA: 9.2 MILLION TONS

California leads the nation with ambitious climate and air-quality policies, and its high-tech businesses are thriving. However, the state also has the seventh-largest potential to provide agricultural co-products for producing bioenergy. California is the nation's number-one agricultural state, and its farmers produce a wide range of fruits, vegetables, milk, and meat. Their top-three commodities by value are milk, grapes,

and almonds—and that means manure and vineyard and orchard prunings are readily available. California has the potential to provide more than 9 million tons of crop residues and manure in 2030, including more than half of the vineyard and orchard prunings available nationwide. California is also a major producer of rice, making rice straw another important source of agricultural residues in the state.

A Promising Path

Biofuels and biopower already play a significant role in our fuel and electricity mix, and have the potential to make an even greater contribution. Researchers at universities across the country are doing pioneering work on converting biomass into biofuels and other chemicals and products. These researchers are especially active at land grant universities, which have an important role to play in improving agriculture in the public interest through teaching and research. For example, engineers, agronomists, and biologists at Iowa State University's BioCentury Research Farm are investigating new ways of processing agricultural residues and other advanced feedstocks into biofuels, while social scientists are analyzing the economic impact of bioenergy on Iowa agriculture.

> ***The promise of biomass as a solution to our energy and oil use greatly depends on what type and how much biomass we use.***

Developing the technologies, practices, and policies needed to use agricultural biomass resources responsibly will ensure that communities across the country benefit both financially and environmentally while the nation curbs its oil and coal use and global warming emissions. However, realizing this opportunity will require private investment and smart public policy.

Moving Toward a Vision of Healthy Food, Healthy Farms, and Low-Carbon Fuels

While agricultural residues and manure are available at large scale from today's U.S. agricultural system, the nation could

Researchers at Iowa State University's BioCentury Research Farm study new ways to process agricultural residues and other advanced bioenergy feedstocks.

develop even better biomass resources over the long term. In particular, perennial crops can play a valuable role as part of an integrated system that improves soil and water quality and reduces the use of chemicals. UCS has a vision for the future of agriculture that includes a better balance among healthy food crops, fewer and less-concentrated livestock, soil-improving cover crops, and low-impact perennial crops for producing energy (UCS 2013).

To realize this vision, we need to make progress on the technology for producing biomass-based fuels and on the transformation of our agricultural system to produce a balanced harvest of healthy food and sustainable biomass at a sensible scale. Managed well, these transformations will complement each other. However, both will take time, so it makes sense to develop the technology for producing biofuel from the resources we have today while we work to improve the agricultural system as a whole over time.

Pursuing a smart path forward for bioenergy—along with improving the efficiency of our vehicles and developing advanced vehicle technology—can help the nation cut its projected oil use by half in 20 years. To learn more about the UCS Half the Oil plan, visit *www.halftheoil.org*. You can also read more about our vision for the future of agriculture at *www.ucsusa.org/healthyfarmvision*.

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Where Do Our Numbers Come From?

The information in this fact sheet is part of a larger UCS assessment of the potential for producing bioenergy from agricultural residues, waste, energy crops, and forest residues. For that assessment, we used data from researchers at the U.S. Department of Energy's Oak Ridge National Laboratory, who have been studying the scale and cost of potential sources of bioenergy for more than a decade.

We conducted a thorough review of their analysis, and made adjustments. For example, we set a stricter threshold for acceptable soil erosion, and capped removal of agricultural residues at a rate that allows soils to maintain their organic matter, or carbon—a key contributor to long-term soil productivity. The threshold we set is a minimum. More sustainable practices and crops would gradually increase the amount of organic matter in soil to enhance the productivity of the land over time.

For our analysis, we also tapped information on agricultural production in various states from the U.S. Department of Agriculture Statistics Service. For our full report on the potential for producing bioenergy from agricultural residues, waste, energy crops, and forest residues, see *www.ucsusa.org/biomassresources*.

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FIND THIS DOCUMENT ONLINE: www.ucsusa.org/agriculturalresidue

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