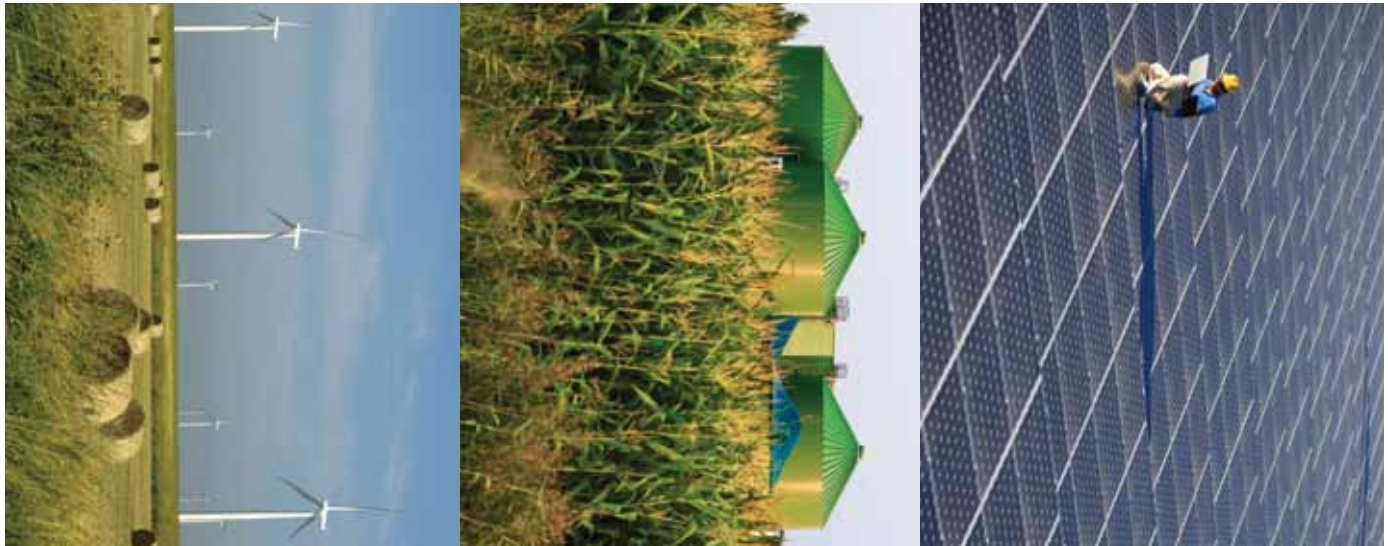
# Beyond Biofuels: Renewable Energy Opportunities for US Farmers.

## A Transatlantic Comparison on a Growing Business for Agriculture

Wilson **Hambrick** Arne **Jungjohann** Amanda **Chiu** Hilary **Flynn**



HEINRICH BÖLL STIFTUNG
The Green Political Foundation

**BEYOND BIOFUELS: RENEWABLE ENERGY OPPORTUNITIES FOR US FARMERS.**

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**by Wilson Hambrick, Arne Jungjohann, Amanda Chiu, and Hilary Flynn**

# TABLE OF CONTENTS

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# EXECUTIVE SUMMARY

"We do not want to be excluded from the national energy policy program. The same can be said for all forms of renewable energy programs. Our concern is that the farmers and local rural communities should not be excluded in favour of opportunities for larger corporations." (*Daryll D. Jamvold,* US Farmer, KS AgraMarke) [1]

As farmers in the 21st century struggle with increasing energy costs and decreasing farm incomes, untapped business opportunities in renewable energy hold the promise of addressing both of these problems, while also offering numerous other benefits such as rural economic development, national energy security and improved environmental conditions. American farmers have captured some renewable energy opportunities available to them, notably those associated with ethanol production, but have not yet developed most renewable technologies to their full potential. German farmers, on the other hand, have used renewables to their advantage and have established a much more robust agriculture-renewables connection than their American counterparts.

Best-practices in utilizing renewable energy can be taken from German farmers and to some degree applied to the United States agriculture sector. Social drivers such as farm lobbies (e.g. Federation of German Farmers), farming cooperatives, rural communities, and banks have all played a crucial role in supporting the development of the renewables industry within the agriculture sector, as has the Germany's comprehensive climate and energy policy strategy.

In the United States, the agriculture sector has traditionally lagged Germany in its ability to capitalize on the benefits of renewables. While farmers in the US are earning revenue from wind and biomass systems, it is at a far lesser degree than German farmers. However, the American agricultural community is increasingly interested in the economic opportunity of renewable energy as well as in the additional benefits to water and soil quality. For example, Germany has approximately 30 times more biogas digesters than the United States.

Continued growth in the German biogas industry is expected as a result of recently amended feed-in tariffs, the same policy that has spurred robust renewable electricity growth in countries like Spain, and Denmark. For a country like Germany, biogas is an attractive domestic substitute for the natural gas imported from Russia. Germany has created significant links between renewable energy and agriculture through strong national policies for renewable electricity, transport fuels, and thermal energy. These policies have been reinforced by support from the national farm lobby, the involvement of communities and cooperatives in renewable energy markets, and by the development of an economically and environmentally sustainable biofuel industry based on biodiesel.

This paper explores lessons learned at the intersection of renewable energy and agriculture on both sides of the Atlantic. The paper provides an overview of renewable energy on farms and discusses the drivers for deployment in Germany and the US. It also compares the German experience to the US and offers suggestions for which drivers in Germany may benefit US farmers. Finally, the paper offers some suggestions for further research and action to help American farmers become "energy farmers" in the 21st century.

# Agriculture and renewables: many synergies

The renewable energy and agriculture sectors have clear, and underexplored, synergies. Vast areas of farmland can be used for wind installations without impacting agricultural yields, and the crops themselves can be used as a source of power or heat generation. Even farm byproducts like animal waste can be converted to biogas and used for heat and electricity generation. Farm-based power generation can be utilized onsite or sold to utilities, while non-electric products (like biofuels, biogas) can be sold to distributors. These options allow the farms to either reduce their own energy costs or receive an income for the products they produce.

Renewables also offer benefits beyond the farm—both to the surrounding rural community as well as to the nation. Renewable energy from farms can aid in developing and strengthening local economies in two ways. First, supplemental services and product providers will emerge in response to renewable energy development in the community, in turn creating jobs[2] and income. Second, revenue flowing to the farm from renewables will be spent locally. Renewables also contribute to the country achieving national goals of energy security and independence, as well as emissions reductions.

Agriculture is increasingly a focus for innovative strategies to reduce greenhouse gas emissions. Globally, the energy sector is the only sector producing more greenhouse gas (GHG) emissions than agriculture.[3] Although US agriculture[4] is not a large emitter of carbon dioxide; it is a major emitter of other GHGs, including approximately 28 percent of the nation's methane emissions and 73 percent of nitrous oxide emissions.[5] Therefore, policymakers are increasingly interested in working with farmers and agricultural organizations to encourage more climate-friendly strategies for existing farming practices, and to enable farmers' investment in low-carbon energy.

The recent developments in renewable energy and agriculture in the US have been mainly in ethanol development. However, other countries are pursuing more aggressive farm strategies that could provide lessons for US policy makers. This paper focuses on Germany, which, despite having a much smaller agriculture industry, has seen a surge of renewable energy development led by farmers.

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## The German renewable energy-agriculture connection

### The German agriculture sector: small and family-owned farms

The German agricultural sector, including forestry and fisheries, accounts for 2.2 percent of employment in Germany and 1.0 percent of the gross national product (GNP). In 2005, the revenue in this sector equaled €45 billion annually.[6] The average size of a German farm is 119 acres—considerably smaller than the average American farm (418 acres). Farms in eastern Germany, however, are on average bigger than their US counterparts. Farms in western Germany average 82 acres on average, while their post-socialist eastern German counterparts cover, on average, 457 acres.[7] Both small-size farms with less than 5 acres and large—size farms with more than 247 acres are common.[8] By 2007, there were nearly 374,500 farms operating in Germany,[9] of which 31,000 are considered large farms. More than 90 percent of German farms are family owned.[10]

## The German renewable energy market: a world leader in investments

The German renewable energy sector is an international leader and one of the most important industries in Germany, employing more than 300,000 people by the end of 2009.[11]

As the prices for conventional fuels rise and become more volatile, and the price for renewable energy technologies steadily falls, the renewable industry's growth will continue. Between 2005 and 2020, the industry aims to invest a total of €200 billion in new generation (€17.7 billion invested in 2009 alone, even with recession) to achieve a 47 percent share in the power sector. By 2020, the industry is expected to employ 500,000 people.[12]

Renewable energy's contribution to total energy consumption[13] in Germany reached 10.1 percent (238 terawatt hour (TWh)) in 2009, avoiding 107 million tons CO2 emissions.[14] Renewable energies represent 16.1 percent (93.5 TWh) of German electricity consumption, 8.4 percent of heat consumption and 5.5 percent of liquid fuel consumption.[15] By 2008, Germany had installed 19.8 percent of the global wind capacity.[16] In 2007, Germany exported nearly €8.5 billion in renewable energy technology. Germany's share of the world market for wind energy turbines and components is nearly 30 percent. Germany is also a global leader in installed capacity of photovoltaic systems, and biogas.

## Renewables on German farms: a growing business

There are many ways that farms have taken advantage of Germany's rapid renewable energy growth. Renewables on farms have been driven by several factors including highly effective national renewable energy policies, supportive farm cooperatives and agriculture lobbies, rural community engagement, and financial institutions knowledgeable in financing farm-based renewable energy projects. This section will discuss the various farm-based renewable energy technologies in Germany, as well as the factors that have promoted their growth over the last few years.

### German farmers: driving wind and PV investments

By the end of, 2009, 21,164 wind turbines with a total capacity of 25,777 MW had been installed in Germany.[17] These turbines generated 39.5 TWh, or 7.58 percent of Germany's net electricity consumption.[18] Nearly one third of Germany's wind capacity was built by local landowners or residents. According to Greg Pahl, a Vermont-based journalist, "individual German investors have installed as much as 4,000 megawatts of wind-generating capacity, an investment of over $4.8 billion. About 200,000 people in Germany own shares of a local wind turbine."[19]

Farmers have been particularly active in wind farm investment and ownership, and have participated in wind energy development projects throughout Germany. Wind development has been active in locations that are not particularly favorable for crops or livestock, but which have strong wind resources such as the northern states of Schleswig-Holstein, Lower Saxony, and Mecklenburg-Vorpommern. In the year 2007, almost 40 percent of electricity consumption (roughly 5,200 gigawatt hours (GWh)) in Schleswig-Holstein was generated by wind turbines.

> In the year 2007, almost 40 percent of electricity consumption in the area of Schleswig-Holstein was generated by wind turbines.

For the year 2020, the state government predicts wind power capacity in Schleswig-Holstein will not only meet 100 percent of its own demand but will also generate power for surrounding states.[20]

Individual farmers and local cooperatives owned the large majority of German wind power in the 1990s (and therefore a large share of the capacity installed worldwide at the time), peaking at approximately 75 percent of the 6,000 MW installed by 2000.[21] Although the share of community-owned systems has declined as other investors have entered the market (i.e. to 45 percent of the market by 2005), [22] farmers remain important players in the German wind industry. Many farmers in Germany also earn additional income by leasing property to wind investors.

A significant number of German farmers have also installed photovoltaic (PV) systems on the rooftops of their barns and in their fields. As a result, German farmers have emerged as an important driver of the global PV market. A survey by the German solar energy association BSW-Solar and Solarpraxis found that there is over 22 GW of PV potential just from the roofs (barns, etc) on farms.[23] Between 2005 and 2008, farmers installed on average 200-250 MW of PV per year, or approximately 20 percent of the German PV market. This was on par with the total amount of PV installed in the US in 2007 (207 MW).[24]

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An important facilitator of this investment trend is the "Maschinenringe"—loosely translated as "machinery syndicate" (see section on social dimensions below). In recent years, these co-ops have increasingly shifted part of their business from standard farm machinery into renewable energy. The reason is simple: for countries like Germany that have to import large shares of their energy, local energy generation adds an additional layer of protection for the country's energy security. Financial support for renewable energy in Germany has been stable, especially when compared to the volatility of farm commodity prices. Therefore, renewable energy is a relatively safe investment for farmers. In addition, farmers strengthen their standing with the public by improving the environment and reducing energy imports from abroad.

While PV and wind have both been success stories on German farms, the most impressive developments in Germany can be found in bio-based renewables.

**Biomass energy in Germany: cover 17 percent of arable land**

In general, German farmers have been active participants in biofuels cultivation. Biofuels, the liquid fuels that are derived from biomass sources and mainly used for transportation, are most often in the form of biodiesel and ethanol. Biofuel production in Germany started as a self-supply business, e.g. to produce biofuels for farm machineries and vehicles. But in recent years, farmers in Germany have been rapidly cultivating energy crops for the larger market. They have also recently begun to grow a more diverse array of crops for energy use. While rapeseed is a well-established source of feedstock for biodiesel, there is currently a boom in corn and other energy crops for the generation of electricity and heat. Field tests are being conducted with fast growing species of trees, such as poplars, as well as new crops such as Chinese silver grass and other grass species. These programs, often supported by the federal and/or state governments, aim to find crops and rotations that are environmentally sustainable while also being economically viable for the farmer.

In 2009, renewable energy resources produced from agriculture occupied almost 5 million acres in Germany, which was approximately 17 percent of the arable land. As is displayed in Figure 1 below, almost half of all crops are rapeseed for biodiesel (2.3 million acres) followed by crops for biogas, such as corn (1.3 million acres), sugar (from beets) and starch combined (560,000 acres).[26] In 2008, overall cultivation area for energy use dropped due to a change in biofuel policies from tax incentives to a quota system. This system increased the demand for imported biofuels and led to a decrease in domestic products.[27]

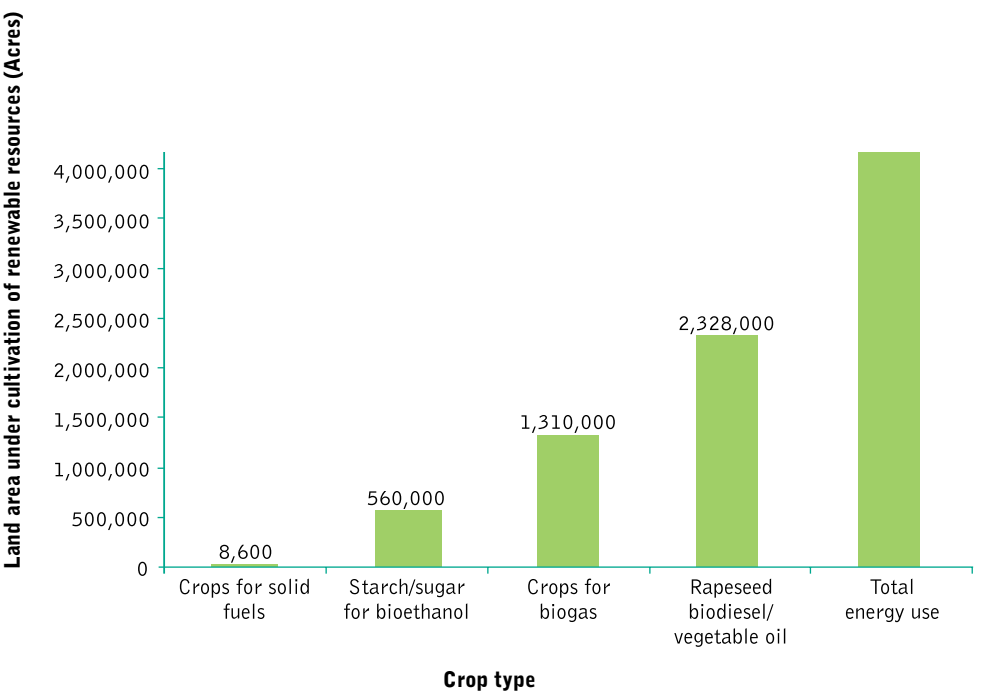



*Figure 1. Cultivation of biomass for renewable energy in acres in 2009 in Germany*[28]

**Solid biomass in Germany: one source of electricity**

In 2007, solid biomass (including wood) contributed 7,390 GWh of electricity generation in Germany which amounted to 1.2 percent of final energy consumption.[29] Although the contribution of solid biomass to Germany's renewable energy portfolio is significant, one of the fastest growing bioenergy sectors in Germany is biogas (which in 2007 provided 7,430 GWh of electricity[30]).

**Biogas in German: the new kid on the block**

Farmers face many water and air quality hazards and odor issues when processing livestock waste. One way to alleviate some of these concerns is by converting the livestock waste to biogas. This can be accomplished through anaerobic digesters, which are systems that use bacteria to decompose manure in an anaerobic environment. Methane is naturally produced in this process.

Biogas is an important fuel in Germany and farmers actively cultivate crops for use in anaerobic digesters. This is a distinct difference from other countries where biogas is primarily generated only from organic waste streams. The biogas sector is growing, and land area used for its cultivation has expanded by nearly 74,000 acres in recent years. The country produced 3.7 million tons oil-equivalent (Mtoe) of biogas in 2008, leading the European Union (EU) in biogas production. The majority of Germany's biogas production (71.2 percent) took place in small farm methanization plants, known in the US as anaerobic digesters. Germany leads the EU in production of biogas-fueled electricity, with 41.7 percent of total EU production, which translates into 8.9 percent of Germany's total renewable electricity and 1.3 percent of overall electricity in 2008.[31] Of the 2008, 86.3 percent of biogas was used in electricity-only power plants, and 13.7 percent powered combined heat and power (CHP) plants.[32]

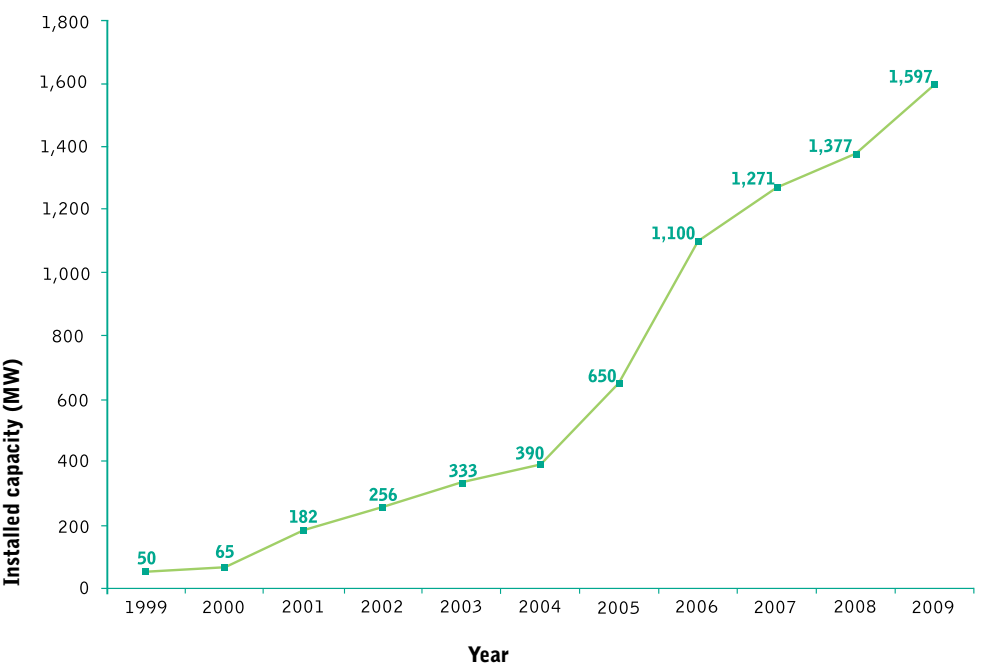



*Figure 2. Installed electric capacity from biogas power plants in Germany, November 2009.*[35]

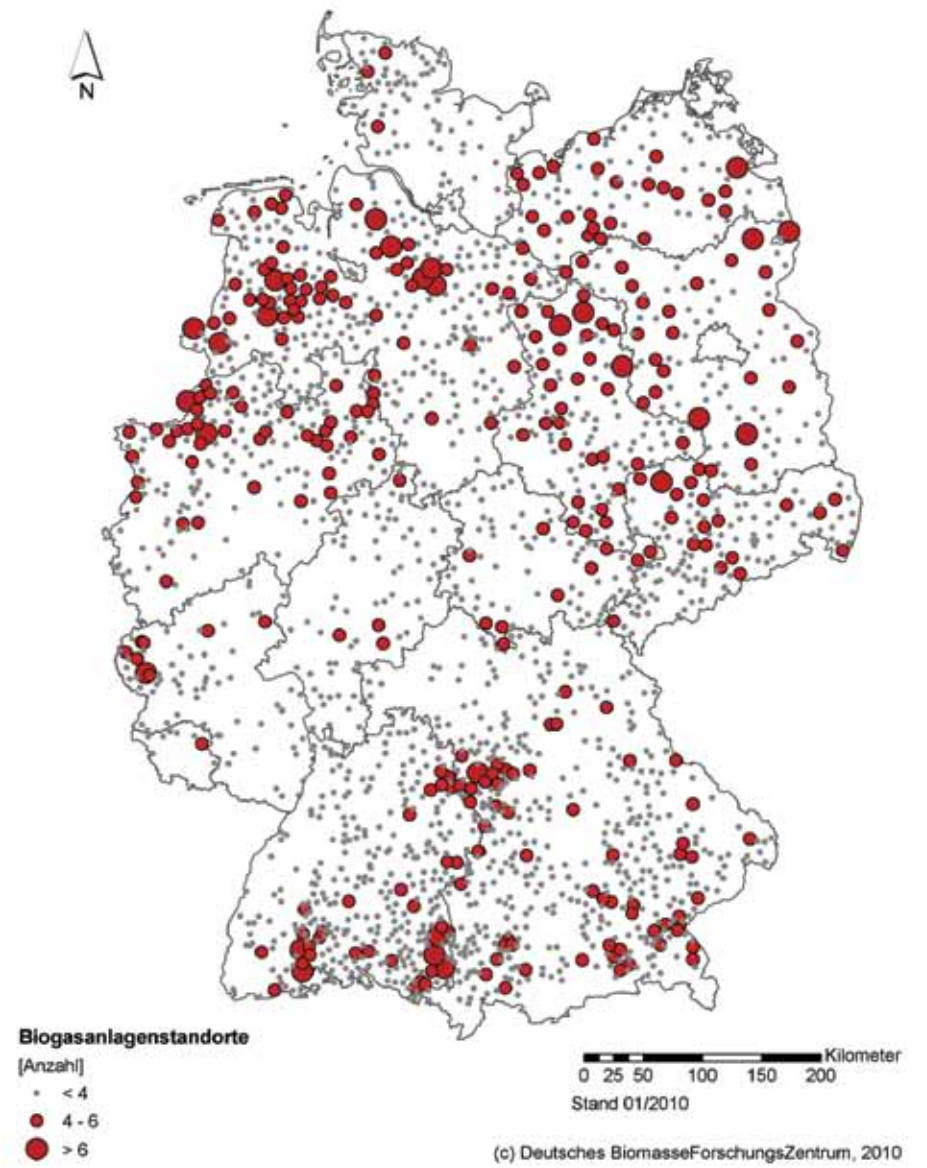



*Figure 3. Number of biogas installations in Germany. German Biomass Research Center. January 2010.*

With the addition of nearly 500 new plants in 2009, the German Biogas Association predicts that Germany's installed biogas plants will exceed nearly 5,000 plants by the end of 2010. With a total output of 1,650 MW (see Figure 2), the existing 4,500 biogas plants cover the annual electricity needs of 3.8 million average households.[33] This boom in construction includes small plants (≤190 kilowatt (kW)) that are experiencing a renaissance due to a bonus payment for farm wastes, as well as larger plants that are being designed to inject their processed biomethane directly into natural gas pipelines (referred to as Renewable Natural Gas or RNG). At present, more than

90 percent of the biogas plants in Germany operate with agricultural substrates.[34]

The growth in the German biogas industry is a result of the recently amended renewable feed-in tariff (see Renewable Energy Sources Act (EEG) in the Appendix), the same policy that has spurred other renewable electricity generation. Amended in June of 2008, the Renewable Energy Act increased the price premium paid to energy producers for electricity and heat generated from renewable resources.

The policy's focus is not technology neutral; it incentivizes innovative technologies in all sizes of installations. To compensate for the higher costs of small-scale installations, feed-in tariff rates for small scale installations are higher. Similarly, systems that utilize agricultural waste receive a bonus payment in order to encourage farm participation. This way, both small and large scale operations are profitable, leading to new investments across the country. Without this diverse approach, there would not likely be many biogas plants in states where smaller farm sizes are typical, such as Bavaria.

However, as a result of the incentives of the feed-in tariff, farmers across the country have invested in small scale biogas (see Figure 3). According to experts like Uwe Fritsche of the German Institute for Applied Ecology, farmers who invested in biogas or PV generate on average a quarter of their income with selling this electricity.[36]

For a country like Germany, biogas is also an attractive domestic substitute for the natural gas imported from Russia. Energy security in Germany would be strengthened by relying more on domestic alternative. The Institute for Applied Ecology estimates that a pan-European biogas-strategy could substitute natural gas imports from Russia completely by 2020 with an economic benefit to the EU of more than €20 billion.[37]

**Biodiesel: the leading renewable fuel in Germany's transport sector**

In the transport sector, biofuels (mainly from rapeseed and biogenic waste) are the only renewable liquid fuel alternative produced in Germany. In contrast to global biofuel production, where ethanol accounts for the vast majority (82 percent), biodiesel in Germany provides 75 percent of the renewable liquid fuel production. The reason for this is the stronger role that diesel fuels play in Europe and particular in Germany. In 2007, almost half of all new personal cars in Germany were diesel engines. In the US, diesel automobiles comprise a far smaller percentage of the market (although US trucking fleets use diesel as a fuel). The high diesel utilization rate is one of the main drivers for demand of biodiesel in the transportation sector. As of 2008, the European Union produced 54 percent (2,112 million gallons) of the global biodiesel supply, with Germany producing one-third of the EU share (750 million gallons).

The development and demonstration of advanced liquid biofuels, especially synthetic biodiesel from biomass-to-liquid (BTL) plants, are currently being supported by the German government and by industry. These plants are expected to slowly enter German markets by 2020, allowing lignocellulosic feedstocks (from energy crops and from residue and wastes) to be converted into liquid biofuels. The core concerns of future bioenergy expansion in Germany, as they are in all of Europe, are sustainability and risks of potential indirect effects, primarily land use change. Unless regulation on the EU level and abroad effectively addresses these concerns, it remains questionable whether bioenergy will find the public and political support needed to fulfill its medium- to long-term prospects.[38]

**Biomass sustainability: Germany moves toward more standards**

A major expansion of bioenergy could create risks and undesirable impacts. Non-sustainable bioenergy strategies would likely contribute more GHG emissions, exacerbate food-security problems, and drive land-use conflicts. As biomass demand in developed countries could be supplied both with domestic and international biomass, these risks have global implications.[39] In Germany, the increasing use of biomass as a resource for renewable energy production is one of several reasons for continued degradation of ecosystems.[40]

For solid biomass, there are no mandatory EU-wide sustainability standards. The EU Commission suggested voluntary standards to EU Member States in February 2010.[41] The recommended criteria relate to a general prohibition on the use of biomass from land converted from forest, other high carbon stock areas and highly biodiverse areas. Additionally, the Commission recommends that biomass be used efficiently, creating GHG savings of at least 35 percent (rising to 50 percent in 2017 and 60 percent in 2018 for new installations) compared to the EU's fossil energy mix. In 2011, the Commission plans to consider whether these sustainability criteria should be improved or be made mandatory at the EU level.

In Germany, however, sustainability standards for solid biomass are required starting in 2011 on the national level.

A major expansion of bioenergy could create risks and undesirable impacts. In Germany sustainability standards for liquid and solid biomass are required starting in 2010 and 2011.

The Biomass Electricity Sustainability Ordinance defines the basic requirements for the sustainability of liquid biomass and the conditions to receive feed in tariffs for bioenergy under Germany's Renewable Energy Law.[42] Similar to the standards on biofuels, it defines rules for the management of agricultural land as well as GHG emissions. In order to prove compliance with the ordinance, certification systems by environmental consultants will be used. In January 2010, the Federal Agency for Agriculture and Food approved the "International Sustainability & Carbon Certification System" (ISCC) as the first system to certify the sustainability requirements of the ordinance.[43] Biofuels used for electricity or heat production already have to comply with the sustainability standard by July 1, 2010. This differentiation—sustainability standards for liquid biomass by July 2010, for solid biomass by January 2011—was driven by the increasing amount of palm oil imports to Germany that is used in CHP plants. The palms oils, imported mostly from Indonesia, are likely more carbon intensive and more environmentally harmful than domestic fuels. [44]

For liquid biomass in the transportation sector, the EU Fuel Quality Directive (98/70/EC) requires EU Member States to transpose sustainability standards into national law. Starting in 2010, Germany requires sustainability standards through the Biofuel Sustainability Ordinance.[45] To fulfill quotas and receive tax concessions, biofuels need to meet certain criteria such as habitat protection and proven net-reductions of GHG of at least 35 percent. Fuels based on biomass from natural habitat and carbon-intensive areas such as wetlands and marsh are prohibited. The standard applies to both domestic and imported biofuels.

## Social, political and economic dimensions of farm-based renewables in German

### The German agriculture lobby: advocating for aggressive renewable energy policies

Over the years, the Federation of German Farmers (Deutscher Bauernverband) has become an advocate of ambitious renewable energy growth in Germany. In the debate on Germany's most recent energy and climate package, the Federation has recommended fast and substantive amendments to improve investment security into biogas installations. It also suggested specific incentives for small and medium-sized installations.[46] In the most recent 2009 debate on cutting feed-in tariff rates for photovoltaics, the Federation of German Farmers warned of the implications of quick and unexpected cuts. It advocated that integrated PV-solutions like modules on rooftops (e.g. barns) become eligible for higher rates.[47]

In preparation for the UN climate summit in Copenhagen in December 2009, the Federation of German Farmers developed a position paper on agriculture and climate protection. It suggested that the German farm and forestry sector be part of the solution to protect the climate, and highlighted the potentials for farmers to become energy producers with bioenergy. In addition, the

federation also outlined the negative impact that climate change would have on farmland and the high costs climate change would impose on German farmers.[48] The Federation has advocated for strategic elements to adapt to climate change and possible contributions by the agriculture and forest sector to mitigate climate change, such as with renewale energy.[49]

The proactive position of the German farm lobby towards climate change does not mean traditional conflicts with environmental groups have disappeared. The farm lobby is being criticized for not fully taking into account the ecological impact of biofuels, and the GHG impact of meat consumption and energy-intensive farm practices. Overall, agriculture contributes to 11 percent of GHG emissions in Germany. Recent analysis shows that there is considerable potential for increased mitigation efforts in this sector which could deliver significant GHG-emission reductions[50]

### Municipalities: playing an important role in rural areas

While large cities like Hamburg and Munich have recently embraced a larger expansion of local renewable energy generation, far more ambitious goals have been pursued in rural towns and villages. Many of these towns are striving for energy autonomy within the coming decades. Rural towns have an abundance of space for the installation of solar, biomass and wind plants; they benefit from close proximity to farmers' biomass for the production of biogas and biofuels; and they have direct access to wood and waste wood for use in modern biomass-fueled boilers.

There are multiple incentives for municipalities to engage in the development of renewable energy projects. First, the production of bioenergy within the German policy framework leads to economic advantages. Biogas, solar and wind plants can compete with fossil fuels once a supportive policy framework is put in place; at the same time, municipalities that use biomass can save on the costs that otherwise would be imposed for waste disposal. Second, there are opportunities for enhanced economic development through the creation of regional business clusters. Farmers are able to utilize all of their products to a significantly higher degree, experts can participate in planning and constructing the facilities, and local craftsmen benefit from the facilities' maintenance needs. Finally, regional energy generation insulates towns and villages from rising global energy prices and volatility.[51]

> The village Sankt Michaelisdorn Schleswig-Holstein has declared its independence. The renewable energy systems of the community already produce four times more energy than its residents use. Fourteen wind power plants produce 80 percent of electricity within the village of 3,650 inhabitants. Additionally, the community has one biogas plant and a PV installation covering 22.23 acres. "Germany depends highly on oil, natural gas, coal and Uranium. Every country should utilize resources that are already possessed. We use the sun, wind and bioenergy for the energy production" said Mayor Volker Nielsen. The honorary mayor and the residents of the community want to switch to 100 percent renewable energy supply, including heating and fuels, within the next 30 years.[I]

Municipalities have a number of options to influence and foster the development of renewable energy production. After setting up a network of regional expertise, they can provide direct stimulus by renting their property for the construction of plants, by streamlining permitting, or by owning and operating their own renewable energy facilities. The popularity of the idea to shift the energy supply of rural areas toward 100 percent renewable is growing across Germany and is actively supported by the German Association of Towns and Municipalities. An annual congress promotes the idea of 100 percent renewable regions.[52]

### Maschinenringe: syndicates of change

Maschinenringe are cooperatives that help farmers to buy their machinery. The role of the Maschinenringe, of which there are over 250[53], is two-fold in the PV market. First, it advises farmers on the size of the investment for a PV installation. Second, it aggregates the orders of several

*Wind mills and other renewable energy investments by farmers are popular among the German public. Taken in St. Michaelisdonn, Germany. Photo by Julia Janssen.*

farmers for PV systems as a way to lower investment costs through bulk purchases. Germany's Maschinenringe Association was quite active in PV from 2003-2008. In that time period they facilitated the installation of over 1,000 PV roof-mounted installations on farms. All of these systems were purchased and owned by the farmers.

### German banks: renewables a solid business

For most banks, participation of farmers in projects is a sign of solid, and even conservative, financial calculation and therefore a low-risk for the bank. For this reason, banks tend to readily offer credit lines and loans to farmers. Banks specializing on the farm sector, such as the Agriculture Pension Bank (''Landwirtschaftliche Rentenbank''), have observed higher demand from their farm clients to invest in renewable energy projects. In 2008, the bank increased its renewable energy portfolio to 955 projects with a total volume of €104 million. This is an increase of 60 percent from 2007. The Deutsche Ausgleichsbank (DtA), a public-private bank that merged in 2003 with KfW, debt-financed roughly 90 percent of all German wind projects (63 percent to limited partnerships, and 12 percent to general partnerships of sole proprietors).[54] The banks expect demand to continue growing in the future.[55]

### Germany's energy policy: clear climate and energy strategy

While solar and wind certainly have a place on farms and will continue to be installed, bioenergy will be a key cornerstone of Germany's future renewable energy policy because:

- Germany has plentiful domestic resources for bioenergy,
- the German government and industry anticipate technological improvements that will make bioenergy even more attractive, and
- bionergy has substantial (and sustainable) import potential from Eastern Europe.

The government's support for bioelectricity, bioheat and biomethane continues on the federal and state level. Liquid biofuels for transport, however, are facing decreasing levels of support, and will face more competition from imported biofuels in the coming years.

In Germany, laws such as the Renewable Energy Sources Act (EEG) (i.e. the national feed-in tariff) and the Oil Tax Law have driven the expansion of on-farm renewable electricity and bioenergy. In addition to legislation, the German Federal Government is supporting the deployment of bioenergy through various research, development and market introduction programs. All of these policies are embedded in the national climate and energy strategy. This strategy includes emission reduction and sector-specific renewable energy targets, including:

- the contribution of renewables to the electricity supply is to be increased to a share of at least 30 percent by 2020 of overall consumption,
- the contribution of renewables to heat supply is to be increased to 14 percent, and
- the share of biofuels in overall fuel consumption is to be 7 percent of net GHG reductions by 2020.[56]

All recent climate-related policies are bundled in Germany's climate and energy package called the Meseberg Program.[57] The package includes 14 laws and ordinances and seven other measures, involving all Ministries that are relevant for climate and energy (e.g. Environment, Economy, Transport, Agriculture, and Research).[58] In addition to this national approach, Germany's strategy is embedded in an overall EU strategy that formulates targets and a policy framework for the EU member states.[59] Pertinent renewable energy policies are listed in the appendix.

## Conclusion and outlook

German farmers have seized the opportunity to become energy entrepreneurs. They have made a concerted effort to invest in renewable energy, and have gained national recognition as a result. Farm lobbies such as the Federation of German Farmers have generally not opposed climate legislation, but have rather fought for more ambitious energy policy to develop renewable resources. A recent survey of the Federation of German Farmers shows that farmers plan to invest significantly in renewable energy. Even in the face of the difficult economy and declining food prices, farmers plan to invest €3.5 billion towards renewable energy in 2010, accounting for 59 percent of their overall investment of €5.9 billion.[60]

In the last decade, a new trend has developed in Germany across the political spectrum to enable farmers to invest in, and profit from, renewable energy. The use of renewable resources for energy provides solutions to a common problem: it gives the agriculture sector and rural areas new options and can help ensure job creation and added value. A common slogan in Germany describing this trend is "Vom Landwirt zum Energiewirt" ("Turning traditional farmers into energy farmers"). This trend was initially promoted by the German Green Party (Bündnis 90/Die Grünen), but has been adopted by all parties and Germany's new center-right government of the conservative Christian Democratic Union (CDU) and the pro-business Free Democratic Party (FDP). With strong political backing, effective community and cooperative involvement, and national recognition of the importance of renewables on farms, the agriculture sector in Germany has been able to boost the financial security of its farmers, strengthen rural communities and contribute to national goals of increased energy independence and climate protection.

# The US renewable energy-agriculture connection

## The US agriculture sector: large farms

According to the most recent agriculture census of 2007, the United States had 2.2 million farms which encompass 922 million acres and have an average size of 418 acres.[61] These farms are larger than the average German farm size of 119 acres.[62] In 2008, 2 to 3 percent of the US population was directly employed in agriculture.[63]

## The US renewable energy market: large, but fragmented

The renewable electricity market in the US, contrary to the situation in Germany, is largely driven by state action, and not federal policy, while the biofuels market is supported by federal policy in both countries.[64] In 2008, renewable energy was responsible for 7 percent of energy consumption in the nation's energy supply (Figure 4) and was approximately 9 percent of total US electricity generation (amounting to over 370 billion kWh)[65] with hydropower being the largest renewable electricity generation source.[66] Renewables increased to over 10 percent in 2009.[67] As of 2007, an estimated 452,000 jobs had been created by the renewable energy industry.[68] In 2008, the US had more installed wind capacity than any other country and ranked fourth in installed solar capacity.[69] State markets remain highly fragmented, however. At the state level, for example, California generates more electricity from geothermal (12.9 million MWh), solar (528 MWdc installed capacity) and wind energy (5.6 million MWh) than any other state in 2009.[70]

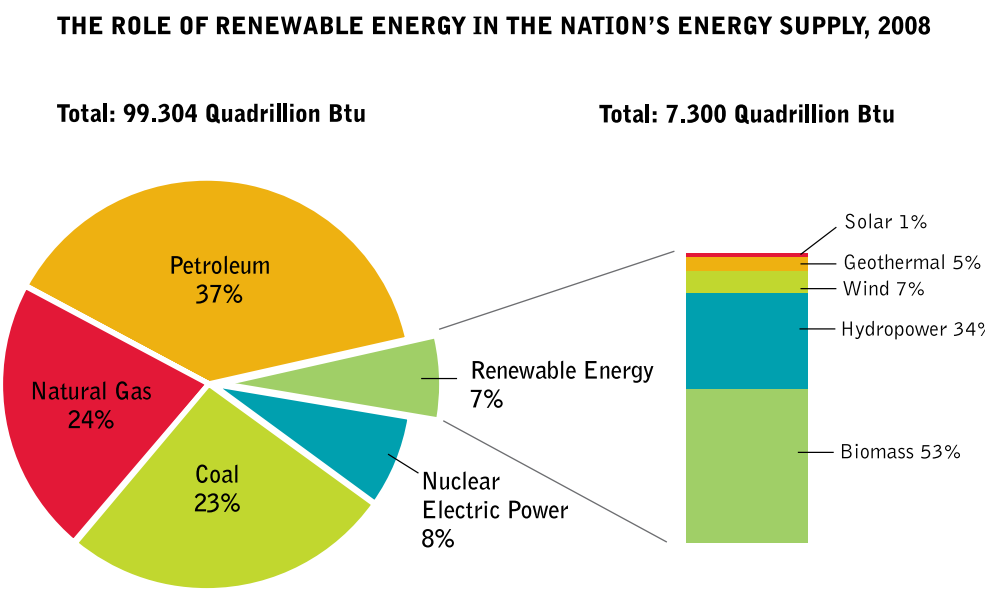



*Figure 4. United States Energy Supply by Source, 2008 (from US Energy Information Administration)*[71]

## Renewables on US farms: diversification needed

Ethanol dominates the US agriculture sector's participation in renewable energy generation, but given the growing concern over ethanol's impact (see 'Biomass Sustainability Issues in the US' section below), there is reason for farmers to diversify into other renewable options. While some drivers present in Germany can be found in the US, it is evident that there are also lessons that can be learned from Germany's experience. This section will discuss the various farm-based renewable energy technologies in the US, as well as the factors that have promoted their growth over the last few years.

### US wind power: farmers miss out on revenue

Vast amounts of farmland in the US provide an opportunity for farmers to either own, or host, wind farms. In a 2001 study, the US Department of Energy estimated that if 5 percent of US electricity was from wind power by 2020, the rural, agricultural area of the US would receive $60 billion in capital investment, $1.2 billion in new income for rural landowners and farmers; and 80,000 new jobs.[72]

Revenue from electricity generation could serve as a steady supplement to the incomes of US farmers and hedge against fluctuating crop and livestock prices. There are several ways in which farmers can take advantage of wind, such as direct turbine ownership or investment, and land lease payments from wind developers.

When considering wind energy projects, landowners weigh the options of investing in their own wind turbines or leasing the land to energy companies that develop wind energy projects. Though revenue earned from the wind project is nearly three times higher when owning and managing the wind turbines, most farmers prefer leasing the land to developers. This is because the energy developers to whom they lease the land can more readily handle the risks, costs, tax benefits and technical matters associated with wind projects.[73] One study found that landowners can expect lease payments of $2,000 to $5,000 per turbine per year.[74] The large majority of US wind power has been installed on privately-owned, rural land and a significant percentage of this land is owned by farmers. While many farmers have benefitted from wind energy land leases, farmers themselves own a comparatively small share of US wind projects. By the end of 2009, farmers and individual landowners owned 638 MW of wind in the US—or approximately 1.8 percent of the 35,170 MW installed nationwide.[75]

Individual landowners have also joined together to achieve economies of scale as wind cooperatives. With this aggregated negotiating platform, cooperative members reap benefits including lower equipment and material costs, a larger presence in the energy marketplace, more community support, and access to low-cost financing—similar to the Maschinenringe in Germany. Members of one pilot project, Our Wind Cooperative, were able to secure extended parts guarantees from their turbine provider; financial support from the National Renewable Energy Laboratory (NREL) and the US Department of Agriculture (USDA), state agencies, and utilities; and an average overall cost reduction of 80 percent through the co-op's cost sharing.[76] They currently have 10 small wind turbines in operation in Washington and Montana, and are selling both electricity and renewable energy credits (RECs, see below for more details on RECs).[77]

Local communities can also derive benefits from cooperative models. A study of eleven US wind facilities found that wind cooperatives create up to 3.1 times more economic benefits and 2.6 times more jobs for the region than does outside turbine ownership. NREL also determined that local turbine owners were more likely to employ neighbors when constructing wind turbines.[78]

While farmers have been taking advantage of wind power either through ownership or property leasing, PV is much less prevalent on farms. The PV market is significantly smaller than wind in the US because PV is comparatively expensive and does not receive the incentives required for large-scale market growth in most states. Analysts at the Interstate Renewable Energy Council estimate that 437.4 MW of PV was installed in 2009, with the majority of this installed in California.[79] Although US farmers have purchased PV systems in many states around the country, there

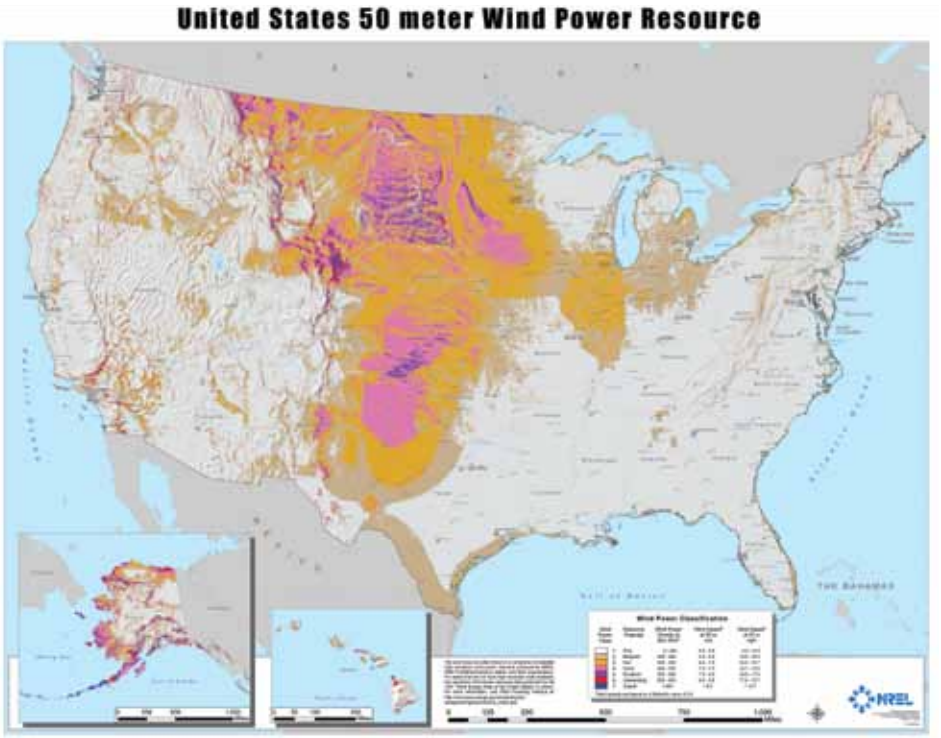



*Figure 5. Wind Rresource map.*

has been no analysis of the total capacity of farmer-owned PV. In total, however, the involvement of the US farm sector in PV has been less significant than that of Germany in terms of both total capacity installed and in terms of the proportional share of total capacity installed nationwide.

There are a wide range of wind and PV policies available from the state and federal government. This section provides a short overview, rather than a comprehensive catalogue.[80] A major policy incentive for the renewable energy industry has been the federal production tax credit (PTC).[81] The PTC was first introduced in 1992 and has amended and expanded to include renewables that farmers can take advantage of, including biomass, anaerobic digestion, wind, and poultry-waste energy. Although a broad range of technologies are eligible for the PTC, the policy has primarily been a driver for the wind industry because it is not sufficiently high[82] to support non-wind generation. Unlike some fossil fuel subsidies which are permanent fixtures in the tax code, the PTC has had a more temporary status, expiring every few years before being reinstated by Congress. This is in stark contrast to Germany where a comprehensive climate and energy strategy with long-term policies until 2020 and beyond is in place.

Because of these lapses in policy support, the wind industry has experienced repeated boom and bust cycles, with a rush of wind capacity coming online following the continuance of the PTC and the market contracting as the PTC expires.[83] The latest PTC extension was approved through the end of 2012, and wind generators can also take advantage of a 30 percent investment tax credit or a 30 percent tax grant in lieu of the PTC as part of the federal governments' stimulus efforts.[84] Photovoltaic generators are also eligible for a 30 percent investment tax credit through 2016 and can take advantage of the cash grant that was also made available through 2010.

Farmers are generally unable to monetize the value of the federal tax credits and so they must frequently enter into different forms of partnerships with tax equity investors.[85] This form of financing can be complex and the transaction costs can serve as a barrier to farmers investing in large-scale renewable energy development either as individuals or as cooperatives.[86] The temporary cash grant, however, has created new opportunities for community- and farmer-owned renewable energy and more streamlined avenues for project investment.[87]

At the state level, Renewable Portfolio Standards (RPS) require utilities to source a percentage of their electricity portfolio from renewable resources. As of March 2010, 29 states and the District of Columbia have a mandatory RPS, with some having special carve-outs for farm-related renewables (see biogas section below).[88] A Renewable Electricity Standard would establish similar renewable energy targets at the national level.

A state-level incentive that has enabled smaller-scale generation is net metering. As of March 2010, 43 states in the US allow renewable energy generators to net meter.[89] Net metering permits renewable energy systems located on the customer side of the meter to be credited for excess electricity that they export to the grid. The level of credit and terms surrounding net metering vary by state, and some states offer added benefits for farmers.[90] Net metering on its own, however, has not been a driver for renewable energy systems without being combined with other federal and state incentives, such as rebates or performance-based incentives.

### Biomass: underutilized in the US

Biomass is perhaps the most obvious renewable energy source for the agriculture sector. A US Department of Agriculture (USDA) study concludes that the US has the capability of supplying 1.3 billion dry tons of biomass from agriculture and forestry by 2030.[91] Of this, one billion tons of biomass could be produced by US farms. Figure 5 shows the total biomass resources by county in the US. (Resource maps for biomass, solar, wind and geothermal are located in the Appendix). While this is feasible without disrupting stock supplies needed for food and fiber markets, such a scenario would require changes to current farming practices, including collecting up to 75 percent of agricultural residue for bioenergy, adding 55 m illion acres of land to energy crop production, and a 50 percent increase in yield from current potential energy crops, such as corn and wheat.[92]

The Haubenschild Farm in Minnesota is an excellent example of the some of the positive possibilities from anaerobic digesters (ADs). This AD generator uses the manure from the 500 cows on the Haubenschild Farm. The excess energy generated from the AD is then sold to a local electric cooperative, the East Central Energy (ECE). The Haubenschild Farm entered into a power purchase agreement with ECE, where the cooperative would buy all of the excess energy from the farm. The ECE then can resell this surplus energy to other customers taking part in the cooperative. Overall, the Haubenschild Farm has been quite successful in the use of its ADs. Nearly 2 million kWh were generated in its first two years of operation. ADs like these are possible in the state, due to an operating subsidy (1.5 cents per kWh) from the Minnesota Department of Commerce. This subsidy is paid over a ten year period to producers who generate electricity from anaerobic digesters.[II]

### Solid biomass electricity and heat: greater potential in the US

In 2008, biomass represented 3.71 percent of total US energy consumption and was used to generate 1.3 percet of the US electricity supply. The Union of Concerned Scientists (UCS) concludes that increasing the use of biomass in the United States to a level where it constitutes 6 percent of US energy supply would bring $20 billion in new income for farmers.[94]

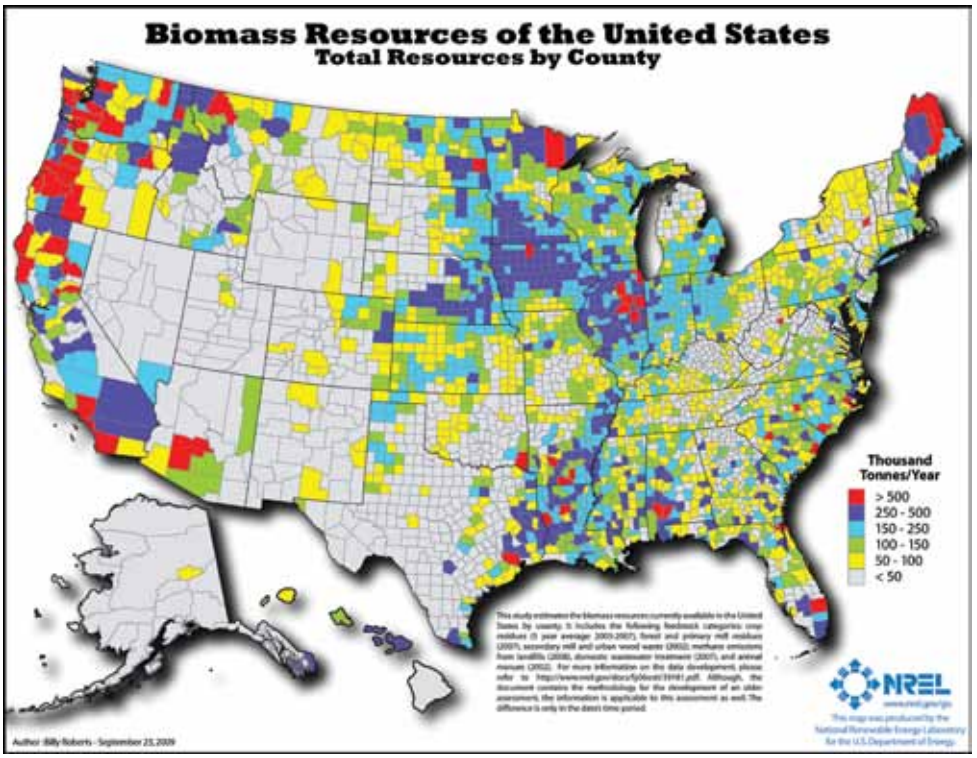



*Figure 6. Biomass resources in the US*[III]

While dedicated biomass-only electricity generation is also a possibility, power generators in the US have primarily used agricultural residue, and to a lesser extent dedicated energy crops and woody biomass, to replace a portion of coal used in power plants in a process called co-firing.[95] Up to 15 percent of coal fuel can be replaced without major modifications to the power plant, and in some cases, co-firing has decreased the cost of fuels.[96]

Biomass is also an effective fuel for heat generation and combined heat and power (CHP), or cogeneration. American industries, especially those for paper and forest products, have been using biomass or product residue like sawdust to generate process heat needed to create products and electricity. Combined heat and power accounts for nearly 9 percent of US electricity-generating capacity.[97] While natural gas is the predominant fuel used in CHP, CHP using biomass, wood, and non-traditional biomass like digester gas account for 3 percent of total CHP capacity in the US.[98]

Biomass can also supply residential and commercial heating needs. Residential wood pellet stoves have been the primary driver for the non-industrial biomass heating market in the US.[99] The commercial biomass heating market in the US is relatively under-developed, as is the residential market for fuels beyond wood pellets.[100]

**US biogas market: small, but growing**

Methane obtained from the anaerobic digestion of both manure and energy crops has proven to be more cost effective than other biomass energy forms.[101] Methane captured from manure through anaerobic digestion can be used as a source of onsite electricity generation, and in certain state markets, excess power can be sold and serve as another form of income.

The number of anaerobic digesters (ADs) in the United States has increased in the past decade. In 2002, there were only 30 ADs in operation in the United States.[102] As of 2008, there were 108 dairy or hog farms using digesters producing a total of 244,000 MWh.[103] This number has since increased to 147 in 2009, as seen in Table 1. As of October 2009, Wisconsin (22), California (16) and New York (21) lead the US in the number of ADs.

Of the ADs in operation in the US, 126 generate thermal or electrical energy from the biogas that is obtained.[105] In all, these ADs avert nearly 39,000 metric tons of methane annually, which is roughly 811,000 metric tons of C02 equivalent.[106] They collectively generate approximately 378,000 MWh each year.

| Farm Type | Numbers of Ads | Installed Capacity (kW) |
|---|---|---|
| Dairy | 120 | 42,307 |
| Swine | 22 | 2,909 |
| Poultry | 3 | 675 |
| Beef | 2 | 2.600 |
| **Total** | **147** | **48,491** |

*Table 1. US Anaerobic Digesters (ADS) by farm type as of January 2010*[104]

Pipeline injection is the process of upgrading this biogas into a cleaner form, biomethane, or renewable natural gas (RNG). Biomass converted into RNG can be fed into existing natural gas pipelines, used in natural gas vehicles or sold to large industrial consumers of natural gas. Upgrading biogas into RNG requires removing hydrogen sulfide, carbon dioxide and moisture.[107] RNG sources include landfill gas, animal waste, sewage and biomass (cellulosic and non-cellulosic) conversion. A DOE study[108] estimates that 1.25 billion quads (or 10 billion gasoline-gallon-equivalent per year) of RNG could be produced from various sources, which amounts to approximately 6 percent of natural gas consumption in the US. Utilities have started signing contracts for RNG to meet their renewable energy goals. For example, in California, Pacific Gas & Electric (PG&E) has committed to buy nearly 6 million MMBtus (MMBtu: million British thermal units) of RNG per year for 10 years from two different RNG companies.[109] PG&E can use the electricity generated from the RNG toward its RPS requirement. [110]

Though small biogas projects on farms in the US have not been as numerous as they have been in Europe—in 2009, 3,000 ADs were operating on small farms in Germany out of the 4,500 installed—recent progress has been driven by federal incentive programs. Anaerobic digesters have received funding through Section 9006 of the 2002 Farm Bill and Section 9007 (REAP) of the 2008 Farm Bill. In 2008 alone, ADs received over nearly $60 million in either loans or grants. The ten projects to which this funding was directed generated nearly 55 million kWh per year. The main benefits available to farmers through this program are lower interest rates, longer repayment terms and higher loan amounts.

Biogas projects also get support from state-level policies, such as RPSs. As mentioned above, some states specify the share of renewable electricity by resource. North Carolina, for example, requires utilities to supply 0.2 percent of their electricity from swine waste by 2018, and 900,000 MWh from poultry waste by 2014.[111] New Hampshire mandates that electricity providers generate the majority of their requisite renewable power from biomass, specifically including biogas. In 2012, at least 6.5 percent of electricity must be from eligible biomass technologies.[112]

**Biofuels in the US: ethanol is king**

Biofuels, the liquid fuels that are derived from biomass sources and mainly used for transportation, are most often in the form of biodiesel and ethanol. The US consumed over 358 million gallons of biodiesel and 6.7 billion gallons of ethanol in 2007. In comparison, the US consumed 53 billion gallons of diesel and 136 billion gallons of motor gasoline in the same year.[113] This equates to biofuels accounting for less than 4 percent of fuel consumption in the US. Though biofuels constitute only a small fraction of the market for transportation fuels, it is anticipated that biofuels will expand to a larger US market share in the future.

While biodiesel is more common than ethanol in Germany, the opposite is true in US. The US produces more ethanol than any other country. In 2008, the US produced nearly 9 trillion gallons of ethanol, nearly 53 percent of all ethanol produced globally. Biodiesel production is much smaller in comparison. In 2008, the US only produced 713 million gallons of biodiesel, ranking globally at third behind Germany and France.[114]

Combustion plants fueled from livestock manure are also an option for farmers, but are not common in the United States. A 55 MW plant called Fibrominn combusts turkey litter collected from over three-hundred farms within a 100 mile radius of the plant. The plant sells the electricity it produces to Xcel under a 21-year contract. Along with creating over 100 full time jobs, Fibrominn has disposed of more than 500,000 tons of poultry litter per year, and farmers have reported earning upwards of $5 per ton of poultry litter. [IV]

As of 2008, 30.8 percent of corn grown in the US was used to produce ethanol.[115] Although corn is currently the most popular (and economically viable) feedstock for producing biofuel, there are many other crop sources have the potential to be both economically and environmentally efficient. As an annual energy crop, corn requires more maintenance and inputs than would a perennial crop such as switchgrass. For example, corn-based ethanol produces more than three times as much C02 per energy unit produced than switchgrass.[116] Switchgrass also has lower water, fertilizer and pesticide requirements than other energy crops. [117]

The Renewable Fuel Standard (RFS) is the primary policy at the national level to support biofuels in the US. The Energy Independence and Security Act (EISA) of 2007 extended and increased the RFS biofuel targets to require annual production of 36 billion gallons of biofuels by 2022. The EPA finalized the new RFS regulations (RFS2) in February 2010. Under this revised RFS2, eligible corn ethanol is capped at 15 billion gallons, and biodiesel targets are ratcheted up to one billion gallons by 2012, with future biodiesel targets to be evaluated at a later date by the EPA. Cellulosic biofuel targets start at 0.1 billion gallons in 2010 and increase to 16 billion gallons in 2022, while advanced biofuels targets are 0.95 billion gallons in 2010 and 21 billion gallons in 2022. The February revisions also defined greenhouse gas emission reduction targets.[118] The EIA estimates that these production targets can be met but not until at least 2027. Better fuel efficiency and more hybrid vehicles are also expected to mitigate some of the projected demand increases for liquid fuels.[119]

### Biomass sustainability in the US: more standards needed

Expanding production of energy crops could have significant environmental impacts on water and soil quality, including pesticide and fertilizer runoff that affects local US water bodies.[120] These compounds, used in crop cultivation, often work their way into surface water during major rain events and negatively affect local aquatic ecosystems. The amount of fertilizers and pesticides applied varies by crop and region, but over-application in some areas has adversely affected water quality in rivers and groundwater in the Mississippi River Basin and some Great Plains states through surface runoff and groundwater infiltration.[121]

Furthermore, agriculture routinely produces high levels of biomass residues from normal agriculture practices. Because this residue provides valuable surface cover that reduces soil erosion, use of this residue as biomass should be accompanied by soil conservation efforts.[122]

Land-use change is also a growing concern in the US, where increasing demand for biofuels has created incentives for landowners to convert land held in conservation into farmland for biofuels, at the cost of soil productivity, water quality, soil erosion, and wildlife habitat.[123]

The effect of biofuel production on food prices has been a heated issue in the US and internationally as well. From 2005 to 2007, the international price of corn increased by 60 percent, partially as a result of the expanding US biofuels program and a decrease in corn exports to other countries.[124] As a result of attractive corn subsidies, in combination with demand for biofuels, farmers have also shifted their production away from other crops such as wheat, which has also ledto rising wheat prices.[125]

The US has begun addressing the long term sustainability of biofuels by requiring greenhouse gas lifecycle analyses that take both direct emissions and indirect emissions into account. For example, in order for corn ethanol to be an eligible fuel under the RFS2, total lifecycle GHG emissions must be at least 20 percent below a 2005 baseline of the gasoline or diesel being replaced. Biofuels such as sugarcane ethanol must meet a similar 50 percent emissions reduction. Biodiesel has a 50 percent emissions reduction requirement, and cellulosic ethanol and diesel must have lifecycle emissions that are 60 percent lower than the replaced fossil fuels.[126]

Non-profit groups and non-governmental organizations have also been developing sustainability standards. One example is the Council on Sustainable Biomass Production—with members from US government agencies, academia, companies, conservation groups, and farmers—which has been building voluntary standards for biomass growers and producers.[127] Another example is the Sustainable Biodiesel Alliance, a US-based nonprofit focused on a voluntary sustainability certification system.[128]

> There are people in Kansas who care a lot more about climate change than their government seems to (...) there is no time to waste to fight global warming. We have got people with ideas and visions, we have got farmers, who are willing to do a new job, so—what are we waiting for?[v]
> *Thomas Beil, European sheep farmer*

## Social, political and economic dimensions of farm-based renewables in the US

### The American agriculture lobby: missing an opportunity?

The largest farm lobby in the United States, the American Farm Bureau Federation (AFBF), supports a national RES[129], especially with a broad definition of biomass, but is skeptical of climate change science.[130] The AFBF released a statement in February 2010 in which it states that it does not support mandatory climate legislation that "is not fair, affordable or achievable."[131] It "also oppose(s) any climate legislation that might impose undue costs on farmers, ranchers and consumers, and that would put US producers at a competitive disadvantage in the international marketplace." However, the AFBF does support voluntary carbon markets that include offsets from agricultural activities. While the AFBF acknowledges that farmers could profit from renewable

technologies and carbon reduction activities, it believes the number of farmers that do benefit will not make up for the many more farmers exposed to higher fuel prices resulting from carbon emission caps. This position is in contrast to the German farm lobby that is more explicitly concerned about the impact of climate change on farmers.

While the AFBF is certainly a large representative of the US agriculture sector, it is not the only voice. The National Farmers Union (NFU) not only calls for a federal RPS but also supports mandatory carbon cap-and-trade legislation.[132] Furthermore, an initiative called the 25x'25 Alliance is calling for 25 percent of total energy consumed in the US by 2025 to come from renewable resources. 25' x 25' has nearly 1,000 members, including agricultural associations and societies, renewable energy companies, state and local governments, and unions such as AFBF and NFU.

In addition to the broad farm lobbies, the US biofuels industry has strong support from crop-specific political organizations. In addition to being a major source of income, farm groups tout ethanol as a domestically produced and renewable energy source that can wean the US away from its dependence on foreign fuels. The National Corn Growers Association (NCGA) is strongly in favor of expanding the market for biofuels. While supportive of the Renewable Fuels Standard, they do not support differentiation among biomass feedstocks for ethanol distribution or retail marketing, and they demand that indirect land-use be a criterion with which to evaluate other energy industries in addition to ethanol. While NCGA opposes anything that would increase electricity prices, they support corn feedstock for electricity and heat and support mandates for biofuel use in government-owned vehicles.[133]

The American Corn Growers Association (ACGA)—a separate organization from the NCGA—also supports the Renewable Fuels Standard as well as a greater mix of renewable energy. It wants to encourage a larger biofuels market through more ethanol refineries and more farmer-owned ethanol refineries in particular, extending ethanol tax incentives, more flex-fuel vehicles, and extending the infrastructure for ethanol distribution.[134]

AFBF argues for more biofuels as part of a comprehensive energy policy. It supports broadening the definition of eligible feedstocks for biofuels under EISA and disagrees with the EPA's approach to calculating lifecycle greenhouse gas emissions, also under EISA.[135] NFU also advocates for a strategic biofuels feedstock reserve as an emergency buffer, similar to the Strategic Petroleum Reserve.[136]

### Municipalities: opportunities for rural development

Community-owned wind farms are one approach to rural development through renewable energy that has a number of success stories. These locally-owned projects are a small component of the wind industry, making up 2 percent of total wind capacity in the US as of 2008, but they offer greater benefits to the local economy, broaden public support for wind power, and open a new source of capital, especially following the recent economic crisis.[137]

For example, Minnesota's Winona County had wide-spread public support for its proposed wind project but faced a variety of challenges including some dissension among the county board, state regulations barring the county from directly investing in its wind resources, and a disastrous flood. While skepticism and natural disasters delayed the process, Minnesota modified its legislation, and Winona County successfully entered into a public-private partnership ownership structure in 2009, and its one wind turbine is expected to be completed in 2010.[138]

Across the nation, rural electric cooperatives, which drew a total 11 percent of their power from renewable resources (mostly hydropower) in 2008, are developing an interest in renewable energy.[139] Rural electric co-ops serve 12 percent of the US, yet they generate only 5 percent of all the electricity produce in the country, 80 percent of which comes from coal.[140] They also own 43 percent of the distribution power lines in the country; investor-owned utilities own 50 percent, and publicly-owned utilities own the rest.[141] Because these cooperatives generally have limited access to capital compared to other utilities, it is all the more significant that some are breaking ground on renewable energy projects.

For example, in December of 2009, North Dakota-based Basin Electric Power Cooperative brought online PrairieWinds ND1, a 120 MW wind farm in North Dakota, now the largest wind farm owned by a cooperative in the US. They have plans for an even larger project in South Dakota called PrairieWinds SD1.[142] Meanwhile Kodiak Electric Association, a rural electric cooperative in Alaska, has developed 4.5 MW of new wind turbines in 2009. This project received a $1 million grant from the state and a $12 million Clean Renewable Energy Bond (CREB) from the Internal Revenue Service (IRS), which together met 57 percent of total project costs, and is the state's first utility-scale wind project.[143]

### US banks: ready to lend

US banks and credit unions that serve the farm community are generally supportive of renewable energy projects, as they are in Germany. The Farm Credit Service (FCS)—a Government Sponsored Enterprise that is a borrower-owned network of lending institutions and insurance companies—provides more than one third of the credit issued in rural America. This major agricultural lender has committed nearly $3 billion to biofuels projects, and has offered financing to nearly 60 ethanol plants.[144] Given that the production of biofuels in the US is predominately in the form of ethanol, it is likely that ethanol was the primary recipient of the largest portion of the FCS funds. These figures highlight a stark contrast between the few large scale projects in the US relative to the many small scale projects in Germany.

### The US's climate and energy strategy: lacking leadership

The federal government continues to debate the need carbon and renewable energy policies, and has no clear comprehensive strategy on climate and energy. A clear, comprehensive strategy would likely spur more renewables on farms as it has in Germany.

## Conclusion and outlook

When compared to Germany, the US has experienced weaker political support, less significant community and cooperative involvement, and generally less national support for farmers to become "energy farmers". While the US agriculture sector has seized on some opportunities in renewables, and initiatives like 25 x 25' are driving support for renewables on farms, there are more opportunities that could be captured. The biggest success story in the US for renewable energy from farms is ethanol. The US is the world's largest producer of ethanol, largely as a result of federal policy support. While the corn-based ethanol industry is making strides in increasing feedstock yields while improving efficiency of production and reducing environmental impacts, the negative environmental and economic implications of corn ethanol suggest that cellulosic biofuels, biodiesel, and other advanced biofuels may be more attractive in the future. Germany, by contrast, has focused primarily on biodiesel production and increasingly on biomass sustainability criteria.

With regard to renewable electricity, German farmers are more involved in generation ownership and investment than their US counterparts. German farmers invested in a significant share of the country's early wind development, and currently own a large amount of Germany's installed PV capacity. Farmers in the US, by contrast, have not yet emerged as significant investors in the utility-scale wind market and are also not significant players in the US photovoltaic industry.

Support from the agriculture lobby in the US does exist for promoting renewables generally, but there is still some resistance to legislation addressing climate change which could further accelerate the renewable energy market. National emission reductions targets and putting a price on carbon through the EU's cap-and-trade system improved the investment conditions for renewable energy. A comprehensive federal policy to combat climate change, with the support of the agriculture lobby, as is the case in Germany, would likely set a different tone across the United States and lead to greater involvement of the agriculture sector in renewables.

Unlike the European Union, the US does not have a federal goal for renewable energy generation. Furthermore, the currently debated Renewable Portfolio Standard addresses only power generation, but leaves out targets for a share of renewable heating and cooling—an important sector to include in renewable energy and climate mitigation goals. The states have been the primary driver of renewables in the US, but state policies have not enabled a significant number of smaller-scale investors (such as farmers) to own generation. The German national renewable energy policy, by contrast, has proven to be a major stimulus for renewable energy and enabled direct ownership of generation assets by farmers.

Federal RPS legislation has been introduced in the US, as has federal feed-in tariff legislation, but neither has been passed. Some states in the US are attempting to follow the example of Germany and other countries by enacting feed-in tariffs as a way to increase renewables quickly.[145] Vermont, for example, was the first state in the nation to pass legislation for a FiT. FiTs typically stipulate that utilities a) sign long term contracts for the electricity that renewable energy projects generate, and b) pay a price for that electricity that is equal to the projects' generation cost, plus a reasonable profit. The FiT program in Vermont provides a stable and financeable revenue stream for generators under 2.2 MW in size, and specifically targets farm-based biogas. The program, which is capped at 50 MW of generating capacity, is currently fully subscribed for solar and biomass projects.[146]

# Recommendations for the US agriculture industry

Although US farms have invested heavily in ethanol for transportation, farm-based renewable electricity as well as biodiesel are much more commonplace in Germany than in the US. This contrast highlights a significant gap between what is possible on US farms and what has thus far been implemented. There are several ways in which the US agriculture industry could draw from experiences in Germany:

1. **US Farmers and their representatives should advocate for state renewable energy policies (specifically feed-In tariffs).** Germany's feed-in tariff law is largely credited with the expansion of renewables in the country. If policies that share similar design characteristics to feed-in tariffs[147] were adopted more widely in the US, farm-based electricity could have a more stable foundation from which to develop. Policies that seek to enable low-risk financing and attract a broader range of investor types—such as farmers—are slowly starting to be implemented at the state level in the US. Lessons can be learned from the German experience on the potential advantages of stable and financeable renewable energy incentives for farm-based renewables. Some agriculture and renewable energy organizations in the US have specifically recommended FiTs similar to Germany's[148] but such policies have yet to be incorporated into the platforms of most interest groups.
2. **US agriculture lobbies should support a comprehensive national climate and energy strategy.** The development of strong national renewable energy policy in Germany has been supported by a broad coalition that has included agriculture lobbies, rural communities, and farming cooperatives. German lobbies such as the Federation of German Farmers, explicitly acknowledge the economic dividends of renewable investments, as well as the threat of global warming, to justify aggressively incorporating renewable energy into the agriculture sector. The US farm lobby, by contrast, has generally supported policies targeting biofuels derived from crops, but has not supported broader climate legislation, such as cap-and-trade.
3. **Rural communities should develop strong stakeholder networks.** German farms have a network of actors, such as community members and cooperatives, that have helped make them successful ''energy farmers''. The profit that flows to farmers from renewable energy activities also benefits local communities, which in turn garners local support for renewable energy projects. In Germany, rural communities have established their own renewable energy goals. In contrast, a similar mobilization of rural communities in support of farm-based renewable energy has not been as widespread in the US, but could be very effective.
4. **The US should diversify feedstocks used for biofuels.** In the recent years, biofuel policy in Germany has been aimed mainly at biodiesel, while the US has put more effort into producing ethanol. In the US, subsidies aiming to increase crop production (mainly corn) for biofuel production have been one of the leading drivers of a dominant ethanol trend rather than biodiesel. In order for the US to have a more sustainable biofuels industry, the US could draw on German and European experience, and continue to explore the development of a more diverse portfolio of renewable transportation fuels.

The lessons from Germany could help US farms and rural communities achieve a broad range of economic, environmental and energy security objectives. Here are some suggestions for further research and actions needed to reach these goals.

- **Raise awareness of farmers and rural communities with an outreach campaign.** An expanded campaign to raise awareness among the farming and rural communities could narrow the gap between potential opportunities for farmers in renewables and their actual participation in the market.
- **Increase farmer-to-farmer exchanges.** Groups with a transatlantic network (such as the Heinrich Böll Foundation and many others) have supported successful exchanges between

agricultural stakeholders in the US and Europe. Such exchanges create opportunities for productive dialogue on renewable energy and help in the implementation of good ideas.

- **Develop a biogas roadmap for the US.** Biogas has enormous potential for farmers. A US roadmap could help states determine how best to pursue biogas installations through the identification of technological options, best policy practices, market drivers, barriers to deployment and other important considerations such as the trade-offs between growing feedstocks specifically for biogas production or using only waste streams . Such analyses at the state level should be complemented by a perspective on how similar activities on the regional or national level could support this development.
- **Create sustainability criteria for biomass in power, heat, and transport.** Although there has been some research on the efficiency and effectiveness of different types of bioenergy, including biopower, bioheat, and biofuels, more work focusing on the opportunities that these resources create for US farmers could add value to current discussions.
- **Support research on policy options.** As new policies are introduced and revised (e.g., the Waxman-Markey bill and next Farm Bill) and considered (e.g., calls for stronger federal action regarding a RES) the specific implications of these policies for farmers needs to be investigated.
- **Evaluate the benefits of renewable energy, distributed generation and energy independence.** Studies have already shown that locally-owned wind projects produce more local benefits compared to commercial projects. As renewable power expands in the US, studies could evaluate the impacts of moving toward a more distributed power structure in rural communities.

# Appendix

## German Renewable Policy

### Renewable Energy Sources Act (EEG)

The most important policy to promote electricity production from renewable sources in Germany is the Renewable Energy Sources Act (EEG)[149] which was first enacted in April 2000, and was revised in July 2004, and again in June 2008. The latest amendment came into force on January 1, 2009. The law offers fixed payments (feed-in tariffs) for every kWh of renewable electricity supplied to the national grid. There are different tariffs according to renewable energy source, conversion technique and plant size. There also additional bonus tariffs to incentivize wood and other renewable resources that have been specifically cultivated for energy production (the "biomass bonus"), for CHP plants ("cogeneration bonus") and for the use of innovative technologies ("innovation bonus").[150] The 2004 revision of the EEG's tariff scheme, which focused specifically on bioenergy, led to a massive increase in the amounts of electricity produced from biomass. The further improvements of the tariff scheme of the 2009 version of the EEG is expected to contribute to a further expansion of electricity (and cogenerated heat) from biogas, and from solid biomass CHP plants. The 2009 EEG authorized the Federal Ministry for Environment (BMU) in cooperation with the Federal Agricultural Ministry (BMELV) to define sustainability requirements for the production of biomass used and the emission reductions achieved when producing electricity from biomass. This power was used in early 2009 to introduce the Bioelectricity Sustainability Ordinance which applies to liquid biofuels used to generate electricity, and which makes the feed-in tariff biomass bonus of the EEG subject to providing proof that the sustainability requirements have been complied with.

### Renewable Energy Heat Act

Germany's Renewable Energy Heat Act (Erneuerbare-Energien-Wärmegesetz) came into effect on January 1, 2009. Its provisions request owners of newly constructed buildings to use renewable energy to meet a portion of their heat requirements. Along with solar and ambient heat, bioenergy and geothermal heat may also be used. Under the act, bioenergy may only be used if it is generated using highly efficient technology (e.g. liquid biomass for conversion to fuel and gaseous biomass in CHP plants). For heat generated from renewables, the provisions of the act give building owners the option to use CHP and energy-saving measures. Owners may also obtain heat from district heating plants if the network is fed from a CHP plant or partially supplied with renewable energy.[151]

### Market Incentive Program for Renewable Energy

Despite its positive environmental effects, bioenergy has only slowly developed in the German market in recent years. Therefore, the federal government and the federal states decided to accelerate its market introduction by various promotional schemes. Beginning in 2000, the federal government has been supporting the purchase of biomass plants (e.g. central heating units using logs or wood pellets, biomass power stations and biogas plants) through its Market Incentive Program (Marktanreizprogramm, MAP). This promotional program has been an impressive stimulus. By mid-2006, a total of 70,846 small biomass plants (< 100 kW) were subsidized at a total cost of €126.5 million, creating a total investment of €1 billion. A loan program by the "Kreditanstalt für Wiederaufbau" (Credit Institute for Reconstruction) has assisted with 1,239 biogas plants, 1,185 biomass heating stations and 60 biomass CHP plants since it first started, representing a total investment volume of €725.5 million. In 2008, the German government made nearly €350 million available for MAP to promote renewables-generated heat. This amount will be increased to as nearly €500 million for the period of 2009 to 2012. MAP research activities will focus on investment in buildings to increase the share of renewable energy in overall heat supply.[152]

**Agricultural Investment Support Program**
Numerous biogas and biomass plants have been built in the agricultural sectors due to the Agricultural Investment Support Program (AFP) of the joint program on "Improving the Structure of Agriculture and Coastal Protection" (GAK). The federal government provides 60 percent of the funding for GAK measures. GAK also provides for bioenergy advisory services, which are currently under review to determine how best to expand their scope.

**Gas Grid Access Ordinance, Gas Grid Payment Ordinance and Incentives Ordinance**
Through the Gas Grid Access Ordinance (GasNZV), Gas Grid Payment Ordinance (GasNEV) and Incentives Ordinance (AregV), Germany improved its ability to feed upgraded biogas (biomethane) into the natural gas distribution grid. This biomethane is then used to supply heat, used in CHP plans, or used in the transportation sector. These policies were amended in 2007 and 2008, and entered into force on April 12, 2008. The most significant changes involved the setting of a 6 percent target by 2020 and a 10 percent target by 2030 for Germany's gas demand to be met with biomethane. The new regulation also helps to remove barriers against the biomethane grid-feed via special provisions, such as uniform quality standards, longer balance periods, greater scope for flexibility and special terms.

**Liquid Biofuel Legislation**
In comparison to other sectors and technologies, the German biofuel framework has experienced highs and lows in recent years. After several years of strong growth, Germany's biofuel consumption declined by 16.5 percent in 2008 (to 3,257 thousand tons oil-equivalent (ktoe)). The biofuel share in the energy content of all ground-transport fuels dropped from 7.2 to 6.1 percent in 2008. This decrease is explained by the federal government's decision to reduce tax exemptions on biofuels and to implement a quota system. Biofuels were free of tax until July 2006 under the oil tax law in Germany, but now fall under the Energy Tax Law. This sets tax rates that rise annually between August 2006 and 2012 until they have reached the level of diesel and petrol. The agricultural and forestry sectors do not have to pay any taxes on biofuels. Since 2007, Germany's Biofuel Quota Act mandates that the petroleum industry set quotas for biofuels. The quota is set at 5.25 percent for 2009 and 6.25 percent for 2010. This is slightly more ambitious than the mandatory standard Germany has to fulfill under EU legislation.[153] Liquid biofuels for transport are regulated by European and national framework conditions. The EU passed Guideline 2003/30/EG in order to increase its share of the market. This commits member states to increase the share of biofuels to at least 5.75 percent by 2010. With the Renewable Energy Sources Directive[154] of December 2008, an EU-wide mandatory target for renewable transport fuels was established requiring each member state to achieve a 10 percent contribution of renewable transport fuels by 2020.

**National Biomass Action Plan**
The aim of the National Biomass Action Plan, as agreed upon by the German Federal Ministries for Environment and Agriculture, is to provide a holistic concept to significantly increase the bioenergy share in Germany's energy supply while also adhering to sustainability criteria.[155] According to this plan, the development of bioenergy will be different in the demand sectors, and will show differences in the assumed increases until 2020.[156]

## US Renewable Policy

**2005 Energy Policy Act**
The Energy Policy Act of 2006 was the first major piece of energy legislation that Congress had passed in nearly 13 years. It has authorized over $50 million annually, over the life of the bill, for biomass grants. The renewable fuel standard (RFS) of this bill required that the annual volume of renewable fuels would go from 4.0 billion gallons per year in 2006 to 7.5 billion gallons in 2012. This number however, would be increased in the 2007 Energy Independence Act. This volume

is apportioned to marketers, refiners and importers on a pro rata basis. To encourage domestic energy production, $4.5 billion was allotted towards renewable energy tax incentives. Also, it set forth the renewable energy goal that 5 percent of all electricity consumption must be derived from renewable sources by 2012. This percentage must be raised to 7.5 percent starting in 2013.

**2007 Energy Independence Act**

The 2007 Energy Independence and Security Act expanded the 2005 RFS. It requires that the total amount of biofuels added to gasoline must be 36 billion gallons by 2022. Out of this amount, 21 billion gallons are required to be produced from non-cornstarch products (such as sugar and cellulose). Furthermore, starting in 2016 all of the increase in the RFS target must be achieved through advanced biofuels. The bill defines these advanced biofuels as cellulosic ethanol and other biofuels developed from non-cornstarch sources.

**2008 Farm Bill**

Other legislation that has helped spur renewable energy development in the agriculture sector is the 2008 US Farm Bill. Section 9007 of this bill is the "Rural Energy for America Program (REAP)." This program provides guaranteed loans and grant—as well as a combination of the two—to assist in the purchase and installment of renewable energy systems for rural business owners and agricultural producers. This program was built off of the 2002 Farm Security and Rural Investment Act, which at the time, only allotted $23 million annually for fiscal years 2003-2007. REAP under the 2008 Farm Bill was allotted $55 million for FY 2009, $60 million for FY 2010 and $70 million for FY 2012. Out of this apportionment, 96 percent has been committed to loans and grants for energy efficiency enhancements and renewable energy systems. Solar, wind, geothermal and biomass projects are eligible for funding support, as is hydrogen power if derived from wind or biomass using geothermal, wind or solar energy sources.[157] REAP and its predecessor has generated substantial outcomes since 2003. Between 2003 and 2008 the USDA either loaned or granted funds to all 50 US states. Over $140 million in grants was awarded in this time period.[158] As of 2008, 2,034 projects had received loan guarantees for a total of $97 million awarded.

**2009 American Recovery and Reinvestment Act**

American Recovery and Reinvestment Act (ARRA) money is being directed at incentivizing both wind and biomass developments, among other renewable energy technologies. Prior to the ARRA, the 30 percent tax credit of the total installed costs of the wind system was capped at $4,000. Since the ARRA, there is no longer a cost cap for building a small wind energy system (a system below 100 kW). Over $14 million is being directed towards wind-technology development, in aims of improving the quality of current turbine components and efficiency. Other actions under ARRA include over $706.5 million being directed towards biofuel research and development in both the public and private sector. Funding that is specifically applicable to agricultural activities includes $110 million directed at the ARRA Biomass Program. Under this program, funds will be used for bioenergy pilot-plant development, biofuel research consortiums and developing feedstock. $20 million is being directed towards ethanol research and development.

**Renewable Energy Production Incentive (REPI)**

The Renewable Energy Production Incentive (REPI) program was launched in 1992 under the Energy Policy Act and amended again in 2005. REPI offers financial incentives for the generation of electricity produced by qualified renewable energy generation facilities, such as wind facilities, anaerobic digesters and biomass technologies, among others.[159] These facilities include not-for-profit electrical cooperatives, public utilities and state governments, among others. Eligible facilities can earn yearly payments of 1.5 cents per kWh (1993 dollars, indexed for inflation) for the first 10-years of operation. From 2001 to 2007 the REPI fund was appropriated $31.6 million and funded programs generated nearly 6.6 billion kWh.

**The Renewable Energy Efficiency Tax Credit**
The Renewable Energy Efficiency Tax Credit applies to biomass technologies and stoves that use qualified biomass fuel. This fuel can be agricultural crops, trees, greases and residues, such as wood pellets. It is a 30 percent personal tax credit for the residential sector, and is limited to $1,500.[160] This tax credit however, is set to expire at the end of 2010.

**US Treasury Renewable Energy Grants**
The US Department of Treasury offers renewable energy grants, which can be applied to wind, biomass projects, anaerobic digesters and many other energy types. The grant was created through the 2009 ARRA. Small wind turbines (up to 100 kW capacity) and biomass facilities are eligible for a grant equal to 30 percent of the basis of the property for small wind turbines. Biomass facilities are eligible for the same grant. So far, the program has awarded nearly $2.3 billion in payments to 253 projects nationwide.[161]

**US DOE Loan Guarantees**
The US DOE offers a loan guarantee program for various technologies, including biomass and wind.[162] Originally enacted under the Energy Policy Act of 2005, this program was recently appropriated $6 billion under the 2009 ARRA. Currently, the DOE may enter into guarantees until September 2011. Applicable sectors for this program include agricultural and manufacturing facilities, among others. Since its inception, this program has mainly focused on projects with project costs over $25 million.

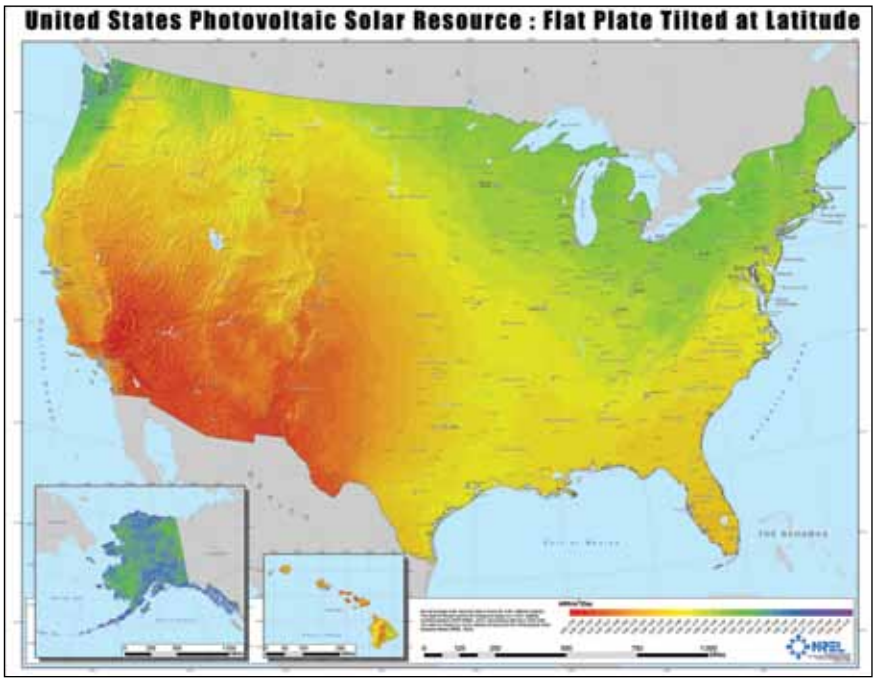
**Biomass Crop Assistance Program**
The Biomass Crop Assistance Program was created in 2002 and assists farmers with matching payments of for the amount paid for harvest, collection, storage and transportation of eligible biomass material. Payments are available to qualified material owners for up to 2 years at a rate of $1 for every $1 per dry ton paid by a biomass conversion facility. Rules proposed by President Obama in February of 2010 intend bring the program funding to $2.6 billion.

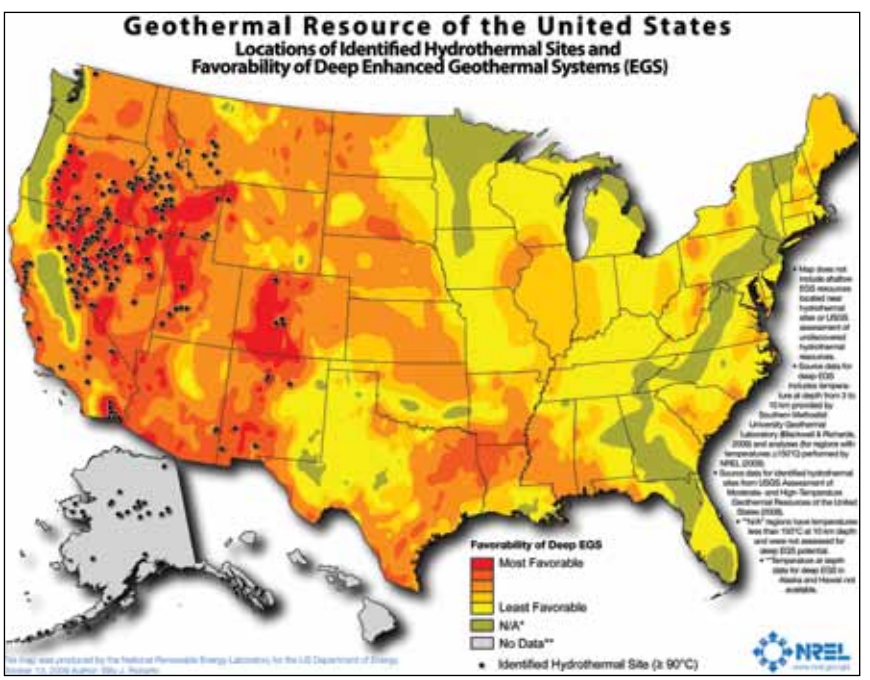
**USDA Rural Energy for America Program—(also see 2008 Farm Bill)**
Various federal agencies offer loan guarantees and grants to encourage and help offset the cost of clean energy investments. The USDA oversees the Rural Energy for America Program which offers a total of $60 million in grants and loan guarantees for renewable energy systems and energy efficiency improvements to rural business owners and agricultural producers. The US Department of Energy administers the Loan Guarantee Program for renewable energy systems including biomass and wind.

## Contribution of Renewable Energy Sources to Energy Supply in Germany, 2007[163]

| | | Final energy | Primary energy equivalent | | Share of final energy consumption | | Share of total primary energy consumption | |
|---|---|---|---|---|---|---|---|---|
| | | | Physical energy content method | Substitution Method | | | Physical energy content method | Substitution Method |
| Electricity generation | | [Gwh] | [Pj] | [Pj] | Share of electricity consumption | [%] | [%] | [%] |
| | Hydropower | 20,700 | 74.5 | 203.6 | | 3.4 | .5 | 1.4 |
| | Wind energy | 39,500 | 142.2 | 374.8 | | 6.4 | 1.0 | 2.6 |
| | Photovoltaics | 3,500 | 12.6 | 31.1 | | 0.6 | 0.1 | 0.2 |
| | Biogenic solid fuels | 7,390 | 65.5 | 65.5 | | 1.2 | 0.5 | 0.5 |
| | Biogenic liquid fuels | 2,590 | 22.9 | 22.9 | | 0.4 | 0.2 | 0.2 |
| | Biogas | 7,430 | 65.8 | 65.8 | | 1.2 | 0.5 | 0.5 |
| | Sewage gas | 1,040 | 9.2 | 9.2 | | 0.2 | 0.1 | 0.1 |
| | Landfill gas | 9.3 | 9.3 | 9.3 | | 0.2 | 0.1 | 0.1 |
| | Biogenic share of waste | 4,250 | 37.7 | 37.7 | | 0.7 | 0.3 | 0.3 |
| | Geothermal energy | 0.4 | 0.0 | 0.0 | | 0.0 | 0.0 | 0.0 |
| | **Total** | **87,450** | **439.7** | **820.0** | | **14.2** | **3.2** | **5.8** |
| Heat generation | Biogenic solid fuels (households) | 57,778 | 208.0 | | Share of FEC for heat | 4.2 | 1.5 | 1.5 |
| | Biogenic solid fuels (industry) | 11,250 | 40.5 | | | 0.8 | 0.3 | 0.3 |
| | Biogenic solid fuels (CHP/HP) | 2,300 | 8.3 | | | 0.2 | 0.06 | 0.06 |
| | Biogenic liquid fuels | 4,500 | 16.2 | | | 0.3 | 0.12 | 0.11 |
| | Biogenic gaseous fuels | 3,461 | 12.5 | | | 0.3 | 0.09 | 0.09 |
| | Biogenic share of waste | 4,910 | 17.7 | | | 0.4 | 0.13 | 0.12 |
| | Solar thermal energy | 3,700 | 13.3 | | | 0.3 | 0.10 | 0.09 |
| | Deep geothermal energy | 160 | 0.6 | | | 0.01 | 0.004 | 0.004 |
| | Near-surface geothermal energy | 2,139 | 7.7 | | | 0.2 | 0.05 | 0.04 |
| | **Total** | **99,198** | **324.7** | | | **6.6** | **2.3** | **2.3** |
| Fuel | Biodiesel | 34,389 | 123.8 | | Share of fuel consumption | 5.6 | 0.9 | 0.9 |
| | Vegetable oil | 8,750 | 31.5 | | | 1.4 | 0.2 | 0.2 |
| | Biothanol | 3,417 | 12.3 | | | 0.6 | 0.1 | 0.09 |
| | **Total** | **44,556** | **167.6** | | | **7.6** | **1.2** | **1.2** |
| **Total** | | **224,204** | **932.11** | **1,312.3** | **FEC** | **8.6** | **6.7** | **9.2** |

## US Resource Maps



## Endnotes

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2 Renewable energy projects create jobs directly related to the construction, operation and maintenance of an installation, as well as indirect jobs that provide associated services and products. For example, biomass studies show that for each job created constructing a biofuel or biopower facility, another four jobs are indirectly created in other linked sectors. For more information see: (Grebner, D., Perez-Verdin, G.,Henderson, J. And Londo, A. (2009). Bioenergy from Woody Biomass, Potential for Economic Development, and the Need for Extension. Journal of Extension: 47 (6): 6FEA7.) Furthermore, the European Wind Energy Association estimates that every MW of installed wind capacity creates 15-19 (direct and indirect) jobs. (See report for more information: American Wind Energy Association: Wind Energy Fact Sheet. Found at, http://www.awea.org/pubs/factsheets/econdev.pdf

3 United Nations Environment Programme: Agriculture, Agro-biodiversity and Climate Change. Found at, http://www.un.org/ecosoc/docs/pdfs/agriculture.pdf

4 For the purposes of this paper references to 'agriculture' refer to both the production of crops and livestock. Furthermore, the issues discussed will be applicable to farms of all sizes, unless otherwise specified. According to the United States Department of Agriculture (USDA), US farms are split up into the following categories:

- Small Family Farms (1,925,799): gross under $250,000
- Large Family Farms (86,551): gross between $250,000–$500,000
- Very Large Family Farms (101,265): gross over $500,000

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8 For the purpose of this paper, the following classifications will be used for Germany's farm sizes: Small-size farms —≤2 hectares (5 acres); Large-size farms—≥100 hectares (247 acres).

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