Spotlight on Biogas

Policies for Utilization and Deployment in the Midwest

August 2010

Published by the Great Plains Institute

Q: How do you maximize the value of organic feedstocks and reduce greenhouse gases while producing clean energy?

A: Biogas deployment and utilization is the answer.

Table of Contents

Preface

Biogas is a renewable energy resource that holds tremendous potential to help meet our future energy needs. As a versatile energy resource, it can be utilized as a feedstock for electricity and/or heat, a source of renewable natural gas, or as a vehicle fuel. Materials that can be used to produce biogas are abundant, especially in the Midwest - an area rich with livestock production, food processing byproducts, and crop residues. Agricultural production is not the only source of biogas production in the Midwest; wastewater treatment facilities, urban wood and yard wastes, and landfills also provide a feedstock source.

The Midwest is behind other parts of the world in deploying biogas technology. Other countries are gaining value from producing natural gas substitutes for transportation, heat, and other purposes. Based on operational experience abroad, the Midwest could produce more biogas from combining multiple organic feedstocks in the same system and developing centralized biogas plants. Such new production models would be instrumental in expanding biogas production beyond the large livestock facilities, where the technology has previously been associated.

Still greater opportunities lie ahead for biogas if we are able to move beyond the models of electricity only production, single feedstock treatment, and on-farm ownership and management of biogas systems. But in order to make that happen, public policy must focus on providing incentives that allow biogas to diversify production and gas utilization models. Changes in public policy may also provide socioeconomic benefits--biogas has the ability to provide a steady and stable source of energy while destroying harmful greenhouse gas emissions. Therefore, the successful scale-up and development of agricultural resources to produce biogas could have a positive economic and environmental impact on rural communities throughout the Midwest.

This report's purpose is twofold: one, to provide an overview of the current policy environment that supports biogas project development, and two, to examine additional policy mechanisms and reforms to current policies that could provide a framework for the increased development of biogas projects.

There are many technologies, both new and emerging, to produce biogas. This report mainly focuses on anaerobic digestion, either at the farm or industrial scale, with an emphasis on agricultural feedstocks (manure, crop resides, food processing byproducts). Landfill gas and wastewater treatment projects are additional sources of biogas production in the United States and are included in the report, but are not the main focus.

Public policy is one of the major limiting factors for increasing the amount of biogas energy production. A deeper, more focused dialogue is needed in the Midwest to determine a comprehensive strategy to capture more energy from agricultural feedstocks and byproducts. Our goal in writing this report is to propose a technology-neutral policy framework that incentivizes and supports the development of biogas projects by agricultural producers and agriculture-related industries in the production and utilization of biogas. This report is the first step in actually creating that framework, by providing an overview of the current policy environment and development of a slate of potential policy options to grow the industry.

Funding for this report was provided by the Energy Foundation.

The Energy Foundation
Toward a sustainable energy future

About the Great Plains Institute

The Great Plains Institute's mission is to accelerate the transition to a sustainable, low-carbon energy system by bringing together key public and private leaders from across the Midwest to:

- Develop consensus on needed policy reforms and see them become law;
- Catalyze development, demonstration and deployment of promising technologies;
- Identify, manage, and sometimes conduct, high priority research that could speed commercialization of such technology
- Deliver targeted public education and outreach on the challenges and benefits of next-generation low-carbon energy options.

The Great Plains Institute strives to be a trusted broker and mobilizing force for energy security, climate stewardship, and economic prosperity. As a non-partisan organization of creative, committed "energy diplomats," we seek to build strong and lasting relationships with the key people and institutions to foster a low-carbon energy system and economy based on the strengths of our region. Leaders in the energy and policy sectors rely on GPI as their local and regional partner for harnessing the talent, technology, policy, and financing necessary for such change.

About the Author

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Prior to joining GPI, Amanda worked for six years with the Minnesota Project in the energy program. Amanda developed deep expertise on anaerobic digester technology and valuable industry connections. Amanda worked with a project team to study the economics, soil quality impacts, and potential weed seed destruction from Minnesota's first on-farm digester at the Haubenschild dairy farm. Ms. Bilek participated in a research project at the Haubenschild farm testing fuel cell technology as an alternative generation option for biogas utilization. And her project work and coordination helped establish one of Minnesota's five on-farm digesters to implement pilot digester technology at a mid-sized dairy farm in Minnesota. She has also authored and coordinated development of several digester reports, factsheets, and web resources. Amanda graduated from the University of St. Thomas in 2001 with degrees in political science and environmental studies and grew up on a diversified crop and livestock farm in Wadena County, Minnesota.

Acknowledgments

Much of the information included in this report would not have been possible without the valuable contributions of many industry stakeholders who contributed their time in discussing these important issues. The author would like to thank the following people for their time and willingness to discuss the topics covered in this report.

Angel Arroyo-Rodriguez	Ohio Environmental Protection Agency
Michael Brown	Xebec
Mike Casper	Microgy
Ray Davy	Agri-Waste Energy
Nettie Drake	AgPower Development, LLC
David Dunn	Central Vermont Public Service
Dennis Frame	Discovery Farms
Allan Goldberg	Iowa Department of Natural Resources
Philip Goodrich	University of Minnesota (retired)
Paul Greene	O'Brien & Gere
Tom Guise	Swedish Biogas
Terry Hall	Baker & Daniels
Adam Halsband	Eisenmann Corporation
Jim Jensen	Environmental Credit Corporation
Bill Johnson	Alliant Energy
Joe Kramer	Energy Center of Wisconsin
Larry Krom	L & S Technical Associates, Inc.
Charlie Kubert	Clean Energy States Alliance
William Lazarus	University of Minnesota, Department of Applied Economics
Bob Lefebvre	Minnesota Milk Producers Association
Nick Mark	CenterPoint Energy
Cecil Massie	6 Solutions, LLC
David Mauney	The Hunter Group, LLC
Shonodeep Modak	GE Energy
Norma McDonald	OWS, Inc.
Dave Miller	Iowa Farm Bureau
Nick Nelson	Midwest Biogas, LLC
Dan O'Neill	Northland Securities
Tim Portz	BBI/Thunderdome Energy
Ralph Rottier	Andigen
Diane Saber	Saber Renewable Energy & Environmental Consultants
Laura Sands	The Clark Group
Kenric Scheevel	Dairyland Power Cooperative
Kathleen Showalter	Enerjyn
Mark Stoermann	Fair Oaks Dairy
Peter Taglia	Clean Wisconsin
Melissa Van Ornum	GHD, Inc.
Michael Vickerman	RENEW Wisconsin
Carol Werner	Energy and Environmental Study Institute
Patrick Wood	AgRefresh
Ryan Young	Blu Skye Sustainability Consulting

The author would also like to acknowledge the valuable assistance of Great Plains Institute staff to produce the report including: Will Overly, Program Associate, for assembling the project highlights contained in this report and conducting necessary background research; Sarah Wash, Communications Specialist, for her assistance editing the report and laying out the print version; and Brendan Jordan, Program Manager, and Patrice Lahlum, Consultant, for reviewing and editing report text.

Additionally the author would like to thank for the following people for taking the time to review a draft of this report: David Dunn, Central Vermont Public Service; Bill Lazarus, University of Minnesota; David Schmidt, University of Minnesota; Pete Taglia, Clean Wisconsin; and Ryan Young, Blu Skye Sustainability Consulting, and Lea Reitmeier and Jen Wagner-Lahr at the Agricultural Utilization Research Institute (AURI) for assembling the information in Appendix D.

Glossary of Terms

Anaerobic digestion (AD): The degradation of organic matter including manure brought about through the action of microorganisms in the absence of elemental oxygen.

Biogas: Gas resulting from the decomposition of organic matter under anaerobic conditions. The principal constituents are methane and carbon dioxide.

Biomethane: Biogas which has been upgraded via a process to remove the bulk of carbon dioxide, water, hydrogen sulfide, and other impurities from raw biogas. The primary purpose for upgrading biogas to biomethane is for use as an energy source in applications that require pipeline quality or vehicle-fuel quality gas. Biomethane is similar to natural gas, except it comes from renewable sources.

British thermal unit (BTU): The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One cubic foot of biogas typically contains about 600 to 800 BTUs of heat energy. By comparison, one cubic foot of natural gas contains about 1,000 BTUs.

Closed-loop biomass: Any organic material from a plant which is planted exclusively for the purpose of being used at a qualified facility to produce electricity.

Combined heat and power (CHP): The sequential or simultaneous generation of two different forms of useful energy—mechanical and thermal—from a single primary energy source in a single, integrated system. CHP systems usually consist of a prime mover, a generator, a heat recovery system, and electrical interconnections configured into an integrated whole.

Complete mix digester: A controlled temperature, constant volume, mechanically mixed vessel designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.

Digestate: Solid material remaining after the anaerobic digestion of a biodegradable feedstock.

Landfill gas: Biogas produced as a result of natural, anaerobic decomposition of material in landfills. Landfill gas (LFG) is typically composed of approximately 55 percent methane and 45 percent CO2 and other trace gases (H2S, sulfur compounds, trace hydrocarbons).

Methane: A flammable, explosive, colorless, odorless, tasteless gas that is slightly soluble in water and soluble in alcohol. The Fourth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC) was used to determine the heat trapping potential of methane in the atmosphere compared to carbon dioxide on a 100-year time frame. The heat trapping potential of methane is 25 times greater than CO2 over 100 years.

Natural gas: A combustible mixture of methane and other hydrocarbons used chiefly as a fuel.

Nonpoint source pollution: Pollution resulting from intermittent discharges of pollutants from diffuse sources and is in transit over land before entering a water body.

Open-loop biomass: includes agricultural livestock waste, agricultural crop by-products and residues, forest-related by-products and residues, and non-hazardous solid wood waste.

Plug-flow digester: A constant volume, flow-through, controlled temperature biological treatment unit designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.

Executive Summary

Organic feedstocks for biogas production are plentiful in the Midwest, but despite their abundance, their use as an energy resource represents only a fraction of total Midwestern renewable energy production. Technical and policy barriers limit the deployment of biogas-to-energy projects.

Biogas can be produced from organic feedstocks such as manure, crop residues, and a variety of wastes from food processing (particularly milk processing waste), wastewater treatment, biomass processing byproducts (such as ethanol stillage or biodiesel glycerol), fats, oils and greases. Once biogas is produced, it can be converted into usable forms of energy on a constant basis, such as: electricity; combined heat and power; natural gas replacement (raw biogas must first be upgraded to biomethane); vehicle fuel; and chemical production. Anaerobic digestion is the dominant technology used to produce biogas via the biological breakdown of an organic material in the absence of oxygen. New technology applications are being developed to produce biogas from solid feedstocks, such as poultry litter or dry feedlot cattle manure and crop residues. Additional developments aim to speed up the feedstock decomposition process using chemical process variations. In new project development models, substrates such as cheese whey or fats, oils, and greases are added to manure digesters to boost biogas production at individual sites. Community models move either the gas or the manure to a central location for processing.

Technical and policy barriers limit the deployment of biogas to energy projects.

Introduction and Industry Background

Europe has long led the rest of the world in biogas project development. Europe not only has the greatest number of individual biogas projects, but has also been a leader in driving technology advancements. Combining multiple organic feedstocks for digestion in the same facility, developing community or cooperative digester models, and advancing new ways to utilize biogas besides electrical production are examples of Europe's technology deployment. The developing world utilizes smaller systems to produce biogas for household heating and cooking fuel. Operational experience in Europe and developing countries provide useful models and information for the Midwest to strategically address biogas scale-up issues.

There is significant potential for new biogas-related projects in Midwest. The entire country could benefit from biogas projects at landfills and wastewater treatment facilities but, given vast agricultural resources and agriculture-related processing industries, the opportunity is especially great for the Midwest. Although there has been growth in the number and scale of operational on-farm anaerobic digester projects in the last decade, the U.S. has not even scratched the surface of biogas project development potential. European countries have had major success in operating biogas projects that combine multiple organic feedstocks for co-digestion. Mixing these feedstocks results in higher biogas production and better management of waste streams. Increasing biogas production at a single site, without additional capital investment, could have a significant impact on project economics and decrease the minimum herd size needed to make a project economically feasible, increasing the number of potential farms as possible project sites. Co-digestion also generates greater volumes of available biogas from individual sites and may entice potential buyers.

A tremendous amount of innovation has taken place in the biogas industry in the last several years. New technology applications and end uses of biogas present real opportunity for additional resource development. However, the current policy environment at the state and federal level does not recognize the immense resource potential from biogas. Without additional mechanisms and

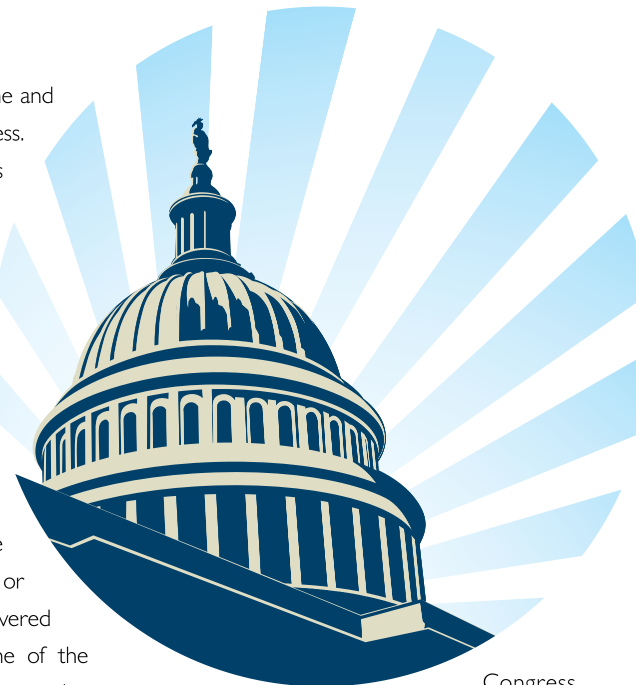
incentives geared towards diverse biogas utilizations and expanded ownership or management models, biogas development will struggle to grow and an opportunity will be missed to diversify our energy supply with a stable and versatile renewable energy resource.

Federal and State Policy Background

Federal policy can have a significant impact on state and local policy efforts. States can design policies to complement federal efforts or take action in an area the federal government has not addressed. Federal policy can provide a broad set of goals and objectives for the entire nation, but rely on state and local efforts to determine the appropriate path for implementation. Historically, production incentives, particularly tax credits, have been the policy instrument of choice to spur renewable energy development. These incentives are crafted to entice renewable energy equity investors. The existing production incentives are geared towards electricity production and do not currently allow for advanced utilization options, such as renewable gas or thermal applications, to qualify for the incentives. Expanding incentive program definitions to allow additional uses of biogas could spur additional project development.

The entire country could benefit from biogas projects but, given its vast agricultural resources and agriculture-related processing industries, the opportunity is especially great for the Midwest.

The climate and energy debate has received an unprecedented amount of time and attention during the 111th Congress. The U.S. House of Representatives passed the American Clean Energy Security Act (ACES) in June 2009. The legislation proposes to put in place a cap-and-trade program, a market mechanism which would issue allowable amounts of greenhouse gas emissions. Covered entities producing fewer emissions than the allowable cap would be eligible to trade or sell extra allowances to other covered entities. Agriculture is not one of the covered entities required to meet greenhouse gas reductions, and instead, agriculture is able to generate carbon offsets to assist covered entities in achieving compliance. Agricultural based biogas projects can generate carbon credits - a verifiable and tradable commodity that places a value on methane emission reductions and provides an additional revenue source for the project. A mandatory carbon market would likely ensure a higher carbon credit price which would improve project financing and bring more projects online. Since carbon credits are based on methane capture and destruction, the incentive would not be tied to biogas utilization as is the case for other existing financial incentives.



Federal regulatory agencies have significant influence on the direction a policy passed by Congress takes when implemented at the state or local level. Biogas projects intersect with Environmental Protection Agency (EPA) regulations for both air and water quality. Although agriculture operations and most related industries will not be subject to the EPA permitting requirements under the Clean Air Act in the near-term, biogas projects stand to benefit from a legislative carbon regulation program where methane capture and destruction projects can sell carbon credits to covered entities. Several economic studies have concluded that the sale of carbon credits by agricultural producers to covered entities under a cap-and-trade program could compensate producers who are likely to face increased input costs. Biogas projects could also be affected by EPA efforts to revise the Confined Animal Feeding Operation (CAFO) rule. Depending on the structure of the revised CAFO rule, biogas development on livestock operations could be a strategy or best practice for manure management.

Midwestern states have implemented several important pieces of legislation that have helped to develop the region's renewable energy resources and build a renewable energy industry. State level policies take the form of renewable energy requirements, net metering, production incentives, voluntary feed-in tariffs or standard-offer contracts and green power purchasing. Existing state policy incentives are focused on electricity generation from produced biogas. New utilizations of biogas are supplying a source of renewable natural gas that can either be upgraded and injected into the existing natural gas pipeline distribution infrastructure or compressed and used as a transportation fuel.

The prevailing policy of choice to drive renewable energy development has been a Renewable Portfolio Standard (RPS) or some form of a renewable energy requirement. An RPS sets a percentage of electricity generation in an electric utility's portfolio to come from renewable energy resources by a certain date. Within an RPS policy states can choose to carve out or set aside a specific percentage of renewable energy generation to be derived from a specific renewable technology. Renewable Energy Certificates (RECs) provide key information about renewable energy delivered to the electric grid. Most states allow utilities to use RECs to demonstrate compliance with an RPS. Renewable Energy Certificates (RECs) sold into a voluntary or compliance renewable electricity market could create a revenue stream for biogas projects. Voluntary purchases by customers through green pricing programs require electric utilities to supply enough renewable energy to meet customer demand. Individuals can purchase RECs directly and do not need a utility green pricing program to make green power purchases.

Net metering has been used as a policy incentive for locally-produced renewable electricity in 35 states. Under a net metering program renewable electricity generated by a utility customer enables the customer to run the electric meter backward to offset electrical use. Biogas policy advocates have been supportive of increasing the capacity limit of current net metering policies to allow more biogas projects to capture the benefit. Even with an increased capacity limit, net metering policies will work for a limited number of biogas projects. Additional policies addressing multiple uses of biogas need to be designed and implemented in order to bring the resource to scale.

Agricultural based biogas projects can generate carbon credits—a verifiable and tradable commodity that places a value on methane emission reductions and provides an additional revenue source for the project.

Feed-in Tariffs (FITs) or Advanced Renewable Tariffs (ARTs) have entered the U.S. policy debate as an option to increase distributed generation of renewable energy resources and provide a payment structure to pull more capital intensive renewable resources into the renewable electricity market. Examining Germany's experience with a FIT policy will be beneficial to U.S. states working to design and implement a similar policy. States will need to design a policy that can be workable within existing regulatory frameworks. The state of Wisconsin is experienced in designing and implementing FITs/ARTs. Alliant Energy, an investor owned utility (IOU) offered a voluntary FIT to customers for renewable energy generation from photovoltaics, landfill gas, wind, biomass, and anaerobic digestion. In early 2009, the Wisconsin Public Service Commission (PSC) began an investigation into the implementation of an ART. Another policy that's similar to a FIT is a standard-offer contract. The state of Vermont offers the best example of a standard-offer contract program. The Vermont Sustainable Prices Energy Enterprise Development (SPEED) program has rapidly been fulfilled and emphasizes the incredible amount of interest among utility customers and project developers to supply renewable electricity to the grid.

Designing a feed-in tariff, advanced renewable tariff, or standard offer policy for individual U.S. states is complicated by existing federal law. The Public Utility Regulatory Act of 1978 (PURPA) and the Federal Power Act of 1935 (FPA) could complicate state efforts to design and implement a FIT policy because these policies only allow utilities to purchase power at avoided cost or at cost-based rates. Individual states and renewable energy advocates have demonstrated a strong interest in examining FIT policy. Correctly designed, a FIT policy could eventually have a large impact on bringing biogas projects to market, but given federal law constraints some nearer-term policy mechanisms should be closely examined.

State regulatory agencies and actions play an important role in facilitating biogas project development. Permitting requirements can also hinder development if the regulations are not clear or uniformly applied. State agencies collaborate with federal regulatory agencies to implement federal rules and regulations in addition to managing state regulatory requirements. State agencies are responsible for issuing a variety of permits required for waste-to-energy projects. Waste-to-energy projects usually fall under air, water, energy, and solid waste regulations. The permitting process can be difficult to navigate for project developers. Regulation requirements become even more complicated when multiple feedstocks are used to produce biogas at a single project site. In addition to permitting requirements, individual U.S. states determine the rules for connecting distributed renewable energy generation projects to the electric grid. These rules cover both technical and legal requirements and, if designed properly, can eliminate confusion and complexity for project developers and electric utilities.

Biogas Policies for Consideration

As the biogas industry has developed over the last several years, the number of experts working in the field has also grown. In order to gain a richer understanding of existing successful policies and those that could be implemented to further help develop the industry, informal discussions took place with a diverse group of industry stakeholders from January to May, 2010. These stakeholders have experience developing and implementing individual projects, advancing policy at the federal or state level, analyzing the current industry, and developing technical and policy solutions to grow the industry.

A common theme expressed by almost all of the stakeholders is a desire for future policy to level the playing field between direct incentives and grants for biogas production that would produce electricity, renewable natural gas, or other utilization options. Private financing from traditional lenders is an obstacle to bring projects online, and future biogas incentives must take into account these commercial lending obstacles. The right policy environment can provide a framework for project developers to determine the highest and best use for the biogas produced and not limit the technology applications for producing biogas or biogas utilization options.

In order to effectively summarize all of the input collected from discussions with 40 industry stakeholders five categories have been developed specifically for the policy discussion:

- **Existing Policies that are Best in Class:** policies that were referenced by a majority of stakeholders as successful examples were placed in this category. Although successful examples exist, it is important to note additional changes could make these programs even more effective.

- **Existing Policies that Just Need a Tweak:** existing policies where a change was recommended were placed this category. Changes recommended were in the spirit of improving the effectiveness of a policy for biogas projects.

- **Proposed Policies that Just Need a Push:** currently proposed policies at the state or federal level that have not been passed were placed in this category. Some policies in this category have seen several attempts at passage

New utilizations of biogas are supplying a source of renewable natural gas that can either be upgraded and injected into the existing natural gas pipeline distribution infrastructure or compressed and used as a transportation fuel.

at the federal or state level or have received a previous level of policy debate.

- **Promising New Policies that Need a Champion:** all new policy ideas not currently proposed as a formal piece of legislation or have not had multiple attempts towards passage were placed this category.

- **Other Ideas:** stakeholder recommendations that do not require or were not ready for legislative or regulatory action were placed in this category.

The chart **Biogas Policies at a Glance** summarizes the high-level policy recommendations gathered from conversations with stakeholders, in addition to model state-level policies and emerging trends outside of the policy arena that hold potential to drive the industry.

The policies, regulatory actions, and ideas presented are solely a starting point for additional discussion and should be considered high- level recommendations. All of the recommendations presented are not final and need additional discussion on specific mechanisms or language required to actually implement the high-level recommendations.

Policy can help to drive an increase in biogas projects, but research is vital to ensure biogas projects increase efficiency and output over time. University level research has played a role in the current biogas industry. Without laboratory and practical research at public institutions, understanding about biogas technology and its effects will be limited. There are additional areas of research that could help to advance project biogas project development in Midwestern states.

The additional development of biogas resources in the Midwest holds significant promise for our agricultural producers, processing facilities, and production industries. Agriculture producers and agriculture-related industries are a major source of potential biogas production. Development of this resource could add economic value to our rural communities and supply a stable, steady, and versatile source of renewable energy. However, current policy does not fully recognize the tremendous potential from biogas. Without additional mechanisms and incentives geared toward diverse biogas utilizations and expanded ownership or management models, biogas development will struggle to grow and an opportunity will be missed to diversify our energy supply with a stable and versatile renewable resource. The Midwest has a unique opportunity to develop biogas resources; the time is ripe, the technology is ready, and the possibilities are endless. It is time for biogas to step into the spotlight and become a part of our energy future.

A common theme expressed by almost all of the stakeholders is a desire for future policy to level the playing field between direct incentives and grants for biogas production that would produce electricity, renewable natural gas, or other utilization options.

Policy Name	Existing Policies: Best in Class	Existing Policies: Just Need a Tweak	Proposed Policies: Just Need a Push	Proposed Policies: Need a Champion	Model State Level Policies	Other Ideas	Industry Trends
American Biogas Council (ABC)							✓
Biogas Production Incentive Act (S.306/H.R. 1158)			✓				
Business and Industry Guaranteed Loans (B&I)		✓					
Business Energy Investment Tax Credit (ITC)		✓					
Carbon Credit Certification Assistance						✓	
Clean Renewable Energy Bonds (CREBS)	✓						
Closed-Loop Projects						✓	
Confined Animal Feeding Operations (CAFOs) Regulations							✓
Divert Source Separated Organics from Landfills				✓			
Enhanced Renewable Energy Standard				✓			
Environmental Quality Incentives Program (EQIP)	✓						
Federal and State Gov't Purchase of Renewable Energy						✓	

At A Glance

Policy Name	Existing Policies: Best in Class	Existing Policies: Just Need a Tweak	Proposed Policies: Just Need a Push	Proposed Policies: Need a Champion	Model State Level Policies	Other Ideas	Industry Trends
Federal Cap on Carbon Emissions			✓				
Federal Renewable Electricity Standard (RES)			✓				
Green Pricing Programs for Natural Gas				✓			
Feed-in Tariffs (FITs) or Advanced Renewable Tariffs (ARTs)				✓			
Integrate Existing USDA Programs						✓	
Iowa Program Implementation Guideline (PIG)					✓		
Increased Coordination and Interaction among Agencies						✓	
Investment Tax Credit for Biomethane Projects			✓				
Low Carbon Fuel Standard (LCFS)			✓				
Model Solid Waste Regulations for Waste-to-Energy Facilities						✓	
National or Individual State Nutrient Trading Programs				✓			
Net Metering Provisions		✓					

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Policy Name	Existing Policies: Best in Class	Existing Policies: Just Need a Tweak	Proposed Policies: Just Need a Push	Proposed Policies: Need a Champion	Model State Level Policies	Other Ideas	Industry Trends
New Federal Agency Initiatives							✓
Nitrogen Oxide (NOx) Emission Regulations							✓
Pennsylvania Nutrient Trading Program for Point Sources					✓		
Premium Price for Consumer Food Products using Biogas Energy						✓	
Project Coordinators						✓	
Renewable Electricity Production Tax Credit (PTC)		✓					
Renewable Fuel Standard (RFS)			✓				
Restrictions on Land Application of Biosolids				✓			
Rural Energy for America Program (REAP)	✓						
Rural Infrastructure Development Fund				✓			
Standard Definition Language						✓	
Standard Gas Quality Specifications and Pipeline Injection Best Practices						✓	
Standard Interconnection Agreements		✓					

At A Glance

Policy Name	Existing Policies: Best in Class	Existing Policies: Just Need a Tweak	Proposed Policies: Just Need a Push	Proposed Policies: Need a Champion	Model State Level Policies	Other Ideas	Industry Trends
State-level Grant Programs	✓						
State-level Renewable Portfolio Standards (RPS)	✓	✓					
Tradable Tax Credits				✓			
Third Party Management Models						✓	
U.S. Department of Treasury, Section 1603		✓					
Utility Conservation Program Investments				✓			
Voluntary Feed-in Tariffs	✓						
Walmart's Sustainability 360 Initiative							✓

Introduction and Industry Background

Organic feedstocks for biogas production are plentiful in the Midwest, but despite their abundance, their use as an energy resource represents only a fraction of total Midwestern renewable energy production.

Biogas is a particularly exciting tool for the biopower toolkit because the energy resource can be used locally or deployed into existing energy delivery infrastructure, and the technology is scalable and can be used as a backup power source for more intermittent sources of renewable energy. As of today, a combination of technical and policy barriers limit the deployment of biogas-to-energy projects.

Anaerobic digestion is the dominant technology used to produce biogas via the biological breakdown of an organic material in the absence of oxygen. This technology can be deployed at varying scales and used to capture biogas from organic feedstocks in landfills, wastewater treatment plants, livestock operations, and processing facilities.

Additional technology applications and utilizations of biogas are emerging as the industry develops in the United States. The intent of this report is not to focus on specific technologies, but to examine prospective policies that would create an investment and regulatory climate conducive to biogas project development. This report does identify specific opportunities for agriculture to produce biogas, but the primary goal is to help lawmakers design technology and gas utilization neutral public policy for biogas projects. The following section provides a brief overview of anaerobic digestion -the dominant technology currently used to capture biogas from a variety of agricultural feedstocks and byproducts.

Technology Overview

Biogas can be produced from organic feedstocks such as manure, crop residues, and a variety of wastes from food processing (particularly milk processing waste), wastewater treatment, biomass processing byproducts (such as ethanol stillage or biodiesel glycerol), fats, oils and greases. Once biogas is produced, it can be converted into usable forms of energy, such as: electricity; combined heat and power; natural gas replacement (raw biogas must be upgraded to biomethane); vehicle fuel; and chemical production.

In the Midwest, some agricultural biogas production exists on individual farms--mostly dairy farms. These operations collect raw manure and process the feedstock through an anaerobic digester for a period of time ranging from five to twenty-two days. The digester vessel is heated to accelerate the biological breakdown of the manure using bacteria, and gas released from manure decomposition is collected, cleaned, and burned primarily in an internal combustion engine to produce electricity.

In the United States, biogas has mainly been used to produce electricity. However, emerging projects are focused on compressing biogas for vehicle use or producing pipeline quality biomethane, which can be injected into a natural gas pipeline or used by an industrial customer. Some on-farm projects have developed additional businesses to use biogas on-farm, such as a greenhouse or a tilapia farm, instead of selling distributed energy. New technology applications are being developed to produce biogas ranging from the use of dry feedstocks, such as poultry litter or feedlot cattle manure, to increasing the speed of the feedstock decomposition process using chemical process variations. In new project development models, substrates such as cheese whey or fats, oils, and greases are added to manure digesters to boost the biogas production at individual sites, and in new types of community models, either raw biogas or manure is transported to a central location for processing.

The presence of new technology applications and project development points toward an exciting future for the expansion of biogas resources in the Midwest and across the country. The United States can also learn a great deal from other countries that have been developing biogas resources for several decades. One need only look at biogas development around the world to conclude that the future of Midwest biogas development is very bright.

European Success with Biogas Projects

Europe has long led the rest of the world in biogas project development. Europe not only has the greatest number of individual biogas projects, but has also been a leader in driving technology advancements for biogas projects. Technology applications include combining multiple organic feedstocks for digestion in the same facility to developing community or cooperative digester models and advancing new ways to utilize biogas besides electrical production. Germany leads other European countries with approximately 4,000 biogas plants in operation. Most are farm-scale projects and utilize biogas to produce electricity and heat (AEBIOM, 2009).

In March 2010, the United Kingdom (UK) Department for Environment Food and Rural Affairs (Defra) published "Accelerating the Uptake of Anaerobic Digestion in England: an Implementation Plan," which grew out of a set of recommendations from the country's Anaerobic Digestion Task Force. The UK recognizes the immense potential for biogas development; Defra estimates the UK produces more than 100 million tons of organic material from food waste, agricultural materials, and sewage sludge each year (Defra, 2010). The implementation plan is a strategic document that tackles the technical and policy improvements needed to scale up the resource. The plan includes creating an economic and regulatory framework, building capacity, conducting research, and sharing global experience.

Europe has also been a leader in the use of upgraded biogas, or biomethane, as a transportation fuel. This technology has most aggressively been used in Sweden, which has had lower electricity prices compared with other European nations and had traditionally utilized biogas for thermal applications. Sweden's focus on advanced uses of biogas has resulted in approximately 25 percent of total current biogas production being upgraded and used as a transportation fuel (AEBIOM, 2009). The project highlight, *100% Urban Transportation in Linköping, Sweden*, demonstrates ingenuity leading the transition of a city's transportation system.

European Technology Transfer

The experience of Linköping, Sweden, to develop a biogas based transportation system presents valuable information and technology that could be put to use in U.S. cities. While a Linköping-type model does not exist in a U.S. metropolitan area today, some mid-size cities are making changes to their transportation infrastructure. Mid-sized cities, like Flint, Michigan, are not waiting around for transportation infrastructure changes to occur elsewhere. The city is taking the lead to diversify their transportation system. Flint, a city hit hard by the decrease in automobile manufacturing, is working closely with Swedish Biogas International (SBI) to transfer knowledge and technology from the Linköping experience to transform the city's transportation system as described in the project highlight, *Flint, Michigan Forms Strong Swedish Partnership*.

Biogas in the Developing World

The developing world utilizes different technology applications to produce biogas. Biogas development in countries like India and China began in the 1940's. In the 1970's, the Chinese government began aggressive promotion, research, and development of individual biogas applications. Today, most of the biogas produced is used on-site by individual households or farms instead of selling the biogas to an outside market. It is estimated that Nepal has 50,000 individual, small-scale anaerobic digesters; China could have close to 8 million small-scale digesters and India over 1 million. These individual digestion projects use the gas produced for household cooking or lighting (Wellinger, 2006). Biogas in the developing world demonstrates a wide range of available technology applications. Operational experience in Europe and developing countries provides useful models and information for the Midwest to strategically address scale-up issues.

Project Highlight: 100% Urban Transportation in Linköping, Sweden

Two decades ago Linköping, a city with a population of 140,000, was concerned about poor air quality from transportation-related pollution. The city chose a solution to their pollution issue unlike that of any other city. Linköping combined the growing amount of slaughterhouse waste and wastewater treatment plant solids with organic feedstocks from local farms, created biogas, and used it to fuel a network of citywide buses. After evaluation of a four-year, five-bus pilot project, an additional plant was constructed. Today Linköping has discontinued the use of animal manure because it contains less energy than other substrates.

By the spring of 1997, a 130 million SEK (about $18 million U.S. dollars) production plant constructed by Swedish Biogas International (SBI) was ready to start supplying the biogas fuel for 27 municipal buses. Since 2002, all town buses have run on biogas and today the plant is fueling 70 city buses, 5 garbage trucks, and 18 filling stations which refuel 1,500 cars and taxis. Furthermore, all the intra-city and intercity buses are in the process of converting to biogas buses. The innovation doesn't stop there—the city has also created the world's first biogas-fueled train, with seating for 54 passengers and an overall range of 600 km (373 miles). To meet transportation demands, Linköping plans on increasing annual biogas production over the next three years from 8 million cubic meters to 21 million cubic meters.

Linköping's decision to pursue the use of biogas in urban transportation has resulted in several positive impacts. The air for the city's 140,000 residents has become much cleaner—it is now almost free of particulate matter, specifically sulfur dioxide and nitrogen oxide compounds. The over 8 million trips provided by the biogas city buses each year have decreased total emissions of fossil carbon dioxide by more than 9,000 tons per year. Today, biogas accounts for 8 percent of the total fuel consumption in Linköping. Besides the environmental benefits, individual Linköping biogas car users can avoid having to pay fuel tax, road tolls, and parking fees in council car parks. Linköping is a great example of how a city can use biogas to solve multiple environmental challenges.

Project Highlight: Flint, Michigan Forms Strong Swedish Partnership

The actions of communities around the world are influencing the way one Michigan city is looking at waste management. Flint, Michigan is collaborating with Swedish Biogas International (SBI) and Kettering University to produce alternative energy from waste at the local wastewater treatment plant. The $8 million biogas project won't require monetary investment from the municipality. Support from the Swedish Agencies STEM / Vinnova, SBI, and a $4 million award from the Michigan Economic Development Corporation (MEDC) will fund the project, which represents an energy efficient waste solution for the wastewater treatment plant and a potential significant cost savings for the city of Flint.

The King of Sweden and Michigan Governor Granholm dedicated Flint's biogas plant -the first in Michigan. The biomethane project is the result of a Michigan law creating the Center of Excellence, a partnership of private business, university and government. The Center of Excellence has six projects in the state with only one focused on producing biomethane as an alternative energy from waste removed from the city's wastewater treatment plant. Biogas created at the plant will be upgraded to pipeline quality natural gas and injected into the pipeline distribution infrastructure. The plant is expected to be operational by end of 2010.

The project will save an estimated $2.5 million over seven years because of the sale of natural gas produced at the plant. The biogas plant is projected to save money for the city and create new jobs. SBI will grow to 5 employees; Kettering University will create 8 research-related jobs, and 15-20 positions will be needed for the construction of the plant. Many cities around the country are closely watching Flint to see if this biogas project can be replicated in their own cities.

Potential for Biogas Projects in Midwestern States

There is significant potential for additional biogas-related projects in the Midwest. The entire country could benefit from biogas projects at landfills and wastewater treatment facilities but, given vast agricultural resources and agriculture-related processing industries, the opportunity is especially large for the Midwest. In order to understand current and future biogas project development opportunities, the author of this report selected a twelve-state region within the Midwest for comparison, including North Dakota, South Dakota, Nebraska, Iowa, Minnesota, Kansas, Missouri, Wisconsin, Illinois, Michigan, Indiana, and Ohio. The following sections discuss operational and potential projects in these twelve states.

Current Landfill Gas Recovery Projects

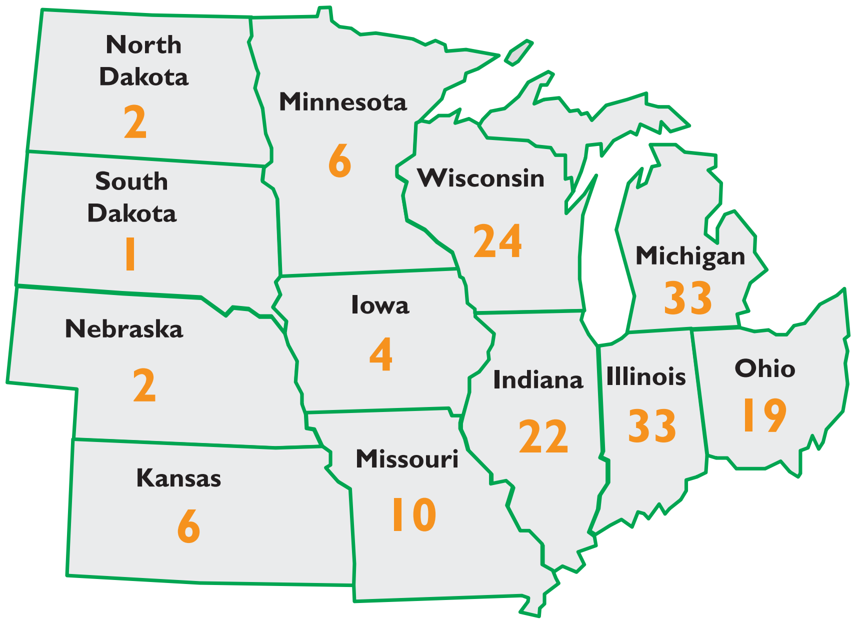
A tremendous amount of organic matter is thrown away each day and ends up in our nation's landfills. According to the Environmental Protection Agency (EPA), municipal solid waste (MSW) landfills are the second-largest source of human-related methane emissions in the United States, accounting for approximately 22 percent of human-related methane emissions in 2008 (EPA, 2010b). When solid waste breaks down in a landfill, methane gas and carbon dioxide is released, which is commonly referred to as landfill gas (LFG). LFG can be captured, converted, and used as an energy resource using a series of wells and a blower/flare (or vacuum) system. The gas is processed and treated for electrical generation, to replace fossil fuels in industrial and manufacturing operations, or to replace natural gas after additional refining (EPA, 2010b).

Although landfill gas recovery projects are not the primary focus of this report, they are an important source of energy and because they are the second largest source of human-related methane emissions -- a gas with 25 times more heat-trapping power than carbon dioxide. Therefore, landfill gas recovery projects are a critical greenhouse gas reduction strategy. Public policy designed to incentivize biogas projects should include LFG recovery projects at existing landfill sites. For more information about landfill gas recovery projects, please visit the Environmental Protection Agency's Landfill Methane Outreach Program website, www.epa.gov/lmop.

Current On-farm Biogas Projects

On-farm anaerobic digestion of animal manure in the United States first took place on a swine operation in Iowa in 1972. As the town of Mt. Pleasant expanded, residents started to live closer to livestock production facilities. Odor complaints helped spur the implementation of an anaerobic digestion system (Lusk, 1998) which, along with the 1970s oil crisis, prompted research and development of alternative energy technologies. Sewage and industrial waste treatment facilities, small-scale projects in India and China, and farm-based systems in Europe were all examined in order to develop pilot scale technology for the U.S. Universities across the country installed small digester systems and conducted basic research.

Midwestern Landfill Gas Recovery Projects



The 1980s brought an investment appetite for operational on-farm anaerobic digester systems, and federal tax credits provided incentives for the construction of more than 100 on-farm digesters. Many of these first systems failed due to poor design, faulty construction, improper operation, and lack of a service infrastructure (Nelson, 2002). Despite poor public opinion about on-farm systems, the AgSTAR Program, a joint program of the U.S. Department of Agriculture (USDA), Department of Energy (DOE), and the Environmental Protection Agency (EPA), saw the potential for on-farm anaerobic digestion of livestock

Project Highlight: Central Disposal System, Lake Mills, Iowa

Waste Management Inc. owns the Central Disposal Systems landfill located near Lake Mills, Iowa. The 621-acre campus has 85 acres specifically devoted to excavation and landfilling and, as of March 2006, is home to a landfill gas-to-energy (LGE) renewable generation facility. The gas at the LGE plant runs six 800-kilowatt Caterpillar 3516 generator units. Dairyland Power Cooperative purchases all of the electric power from the 4.8 megawatt LGE plant, which is able to power 4,000 homes.

Heartland Power Cooperative, a member of Dairyland Power Cooperative, played an important role in making the landfill gas-to energy project possible by proposing the idea to Central Disposal Systems in 2001. Five years later, the trash that Thompson and Lake Mills residents throw in their garbage now powers their homes. As the trash in the landfill decomposes, it produces methane gas, which is collected and piped underground to the LGE plant.

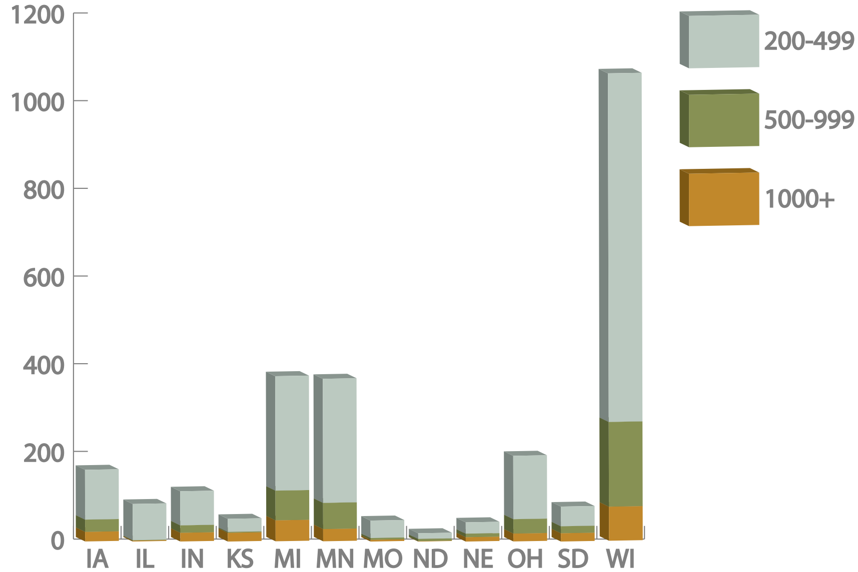
Dairyland's president and CEO Bill Berg says that landfill biogas generation is a win-win for consumers and the environment. It is a win-win because landfills are unlikely to run out of trash or methane, thus ensuring a reliable energy resource while reducing harmful methane gas emissions. Dairyland has three LGE projects that create the same annual benefit as planting 115,000 acres of forest, removing emissions equivalent to 80,000 vehicles, averting the electricity usage of 754,000 light bulbs, and offsetting the use of 2,000 rail cars for transporting coal. The project has also installed a heat recovery system. Recently a one-acre greenhouse was co-located by the LGE plant to utilize recovered heat to grow organic tomatoes for distribution throughout the Upper Midwest. In this northern Iowa township, trash is now the community's treasure.

manure and funded twelve charter farm projects in the late 1990s to demonstrate technological advancements in system design. Successful system operation at selected charter farms demonstrated that significant progress had been made in system design and provided greater assurance for future projects. According to AgSTAR, as of April 2010 there are 151 operational agriculturally based anaerobic digestion projects, 13 of which are centralized or regional projects (U.S. AgSTAR, 2010).

Although there has been growth in the number and scale of operational on-farm anaerobic digester projects in the last decade, the U.S. has yet to scratch the surface of biogas project development potential. Data from the 2007 Census of Agriculture illustrates the Midwestern potential for biogas projects using livestock manure, Figures 1-4. Data was collected from the National Agricultural Statistics Service (NASS) examining a 12-state Midwestern footprint in the dairy, swine, cattle, and poultry layers sectors. These four livestock sectors were selected because each sector has at least one operational biogas project in the Midwest.

Three different categories of potential projects were established. The orange category shows a conservative estimate, representing the largest livestock operations in the Midwest. The green category is a more aggressive category, representing mid-sized operations, and the blue category is a stretch category, looking at the smallest farms. The potential for project development in both the green and blue categories would need to be accompanied by new technology and project development models. These categories are included to demonstrate the absolute potential for resource development as new technologies become available and do not assume that project development can occur in the near term without public policy changes and technology advancements.

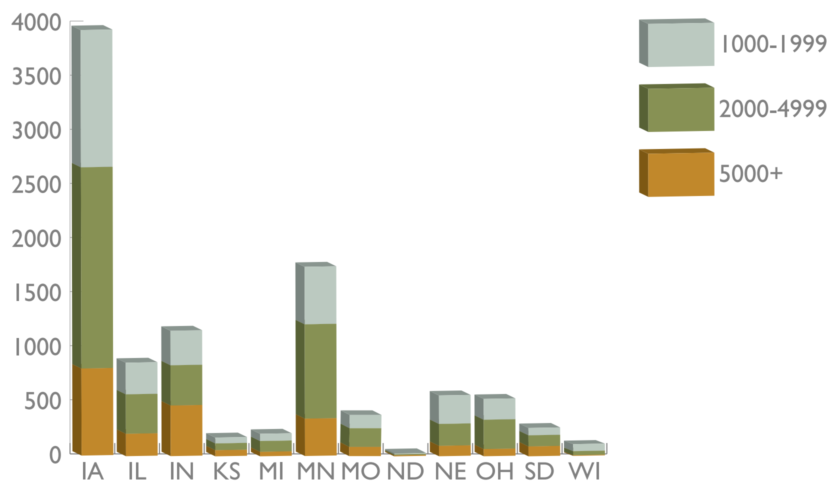
Figure 1. Midwestern Dairy Farms



Dairy Farms	IA	IL	IN	KS	MI	MN	MO	ND	NE	OH	SD	WI	Total
1000+	22	2	20	20	48	28	4	1	10	18	19	78	270
500-999	28	1	17	2	68	60	4	5	8	33	16	194	436
200-499	114	83	78	30	262	284	40	13	26	145	45	798	1918

Source: USDA National Agricultural Statistics Service (NASS), 2007 Census of Agriculture

Figure 2. Midwestern Swine Farms



Swine Farms	IA	IL	IN	KS	MI	MN	MO	ND	NE	OH	SD	WI	Total
5000+	808	208	470	57	42	347	86	10	97	67	92	7	2291
2000-4999	1866	366	373	63	100	875	173	8	203	272	103	37	4439
1000-1999	1273	293	320	54	67	533	123	10	264	193	68	65	3263

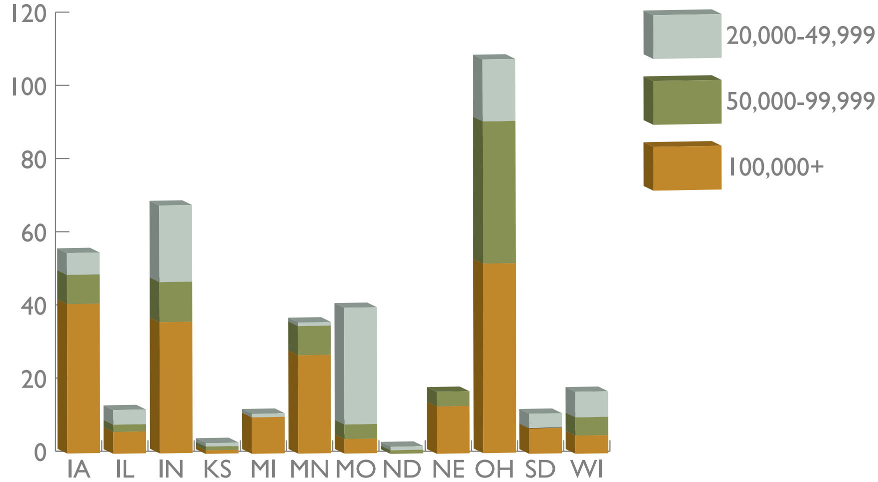
Source: USDA National Agricultural Statistics Service (NASS), 2007 Census of Agriculture

Co-digestion of Multiple Feedstocks

European countries have experienced major success in operating biogas projects that combine multiple organic feedstocks for co-digestion. Two main issues with the European model propelled the use of centralized anaerobic digesters using multiple feedstocks. First, wastewater treatment plant digesters were usually oversized and substrates had to be added to use the full capacity of the system. Second, manure-only biogas production was not economically feasible at the energy prices of the day, given that manure produces relatively low amounts of biogas on its own (Wellinger, 2006). Mixing these feedstocks resulted in higher biogas production and better management of waste streams. Increasing biogas production at a single site, without additional capital investment, could have a significant impact on project economics and decrease the minimum herd size needed to make a project economically feasible, increasing the number of potential farms as possible project sites.

Co-digestion also generates greater volumes of available biogas from individual sites and may entice potential buyers. A natural gas or electrical utility could buy at scale without having to invest in additional infrastructure. Figure 5 compares the biogas production potential of different substrates that could be used for co-digestion. The Midwestern region is rich with these feedstocks. Co-digestion has the ability to significantly increase the number of the potential projects and produce more biogas at individual sites. Co-digestion of multiple organic feedstocks is an idea that is beginning to take shape in the United States, and there are projects already underway and increasing their output. The project highlight, *Co-digestion at the Jer-Lindy Dairy*, demonstrates the possibility for farmers with small- to medium-sized dairy herds to become biogas producers, providing a reliable, renewable energy resource for their communities.

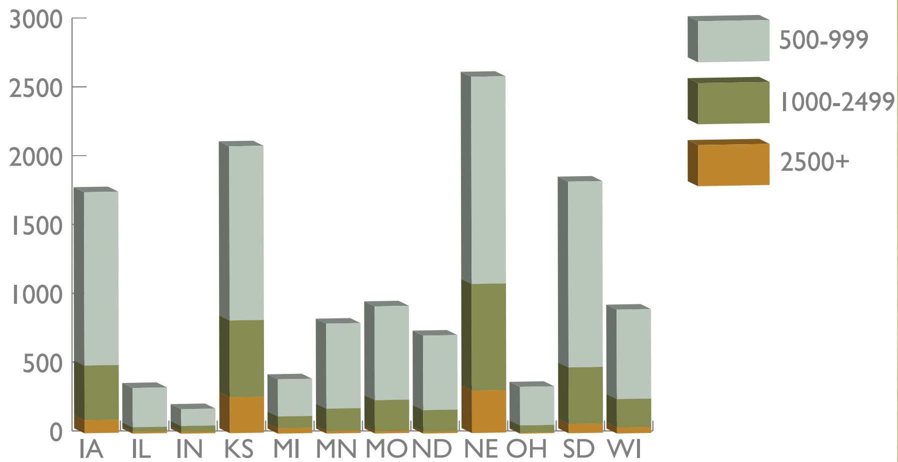
Figure 3. Midwestern Poultry Layers Farms



Layers Farms	IA	IL	IN	KS	MI	MN	MO	ND	NE	OH	SD	WI	Total
100,000+	41	6	36	1	10	27	4	0	13	52	7	5	202
50,000-99,999	8	2	11	1	1	8	4	1	4	39	0	5	84
20,000-49,999	6	4	21	1	0	1	32	1	0	17	4	7	94

Source: USDA National Agricultural Statistics Service (NASS), 2007 Census of Agriculture

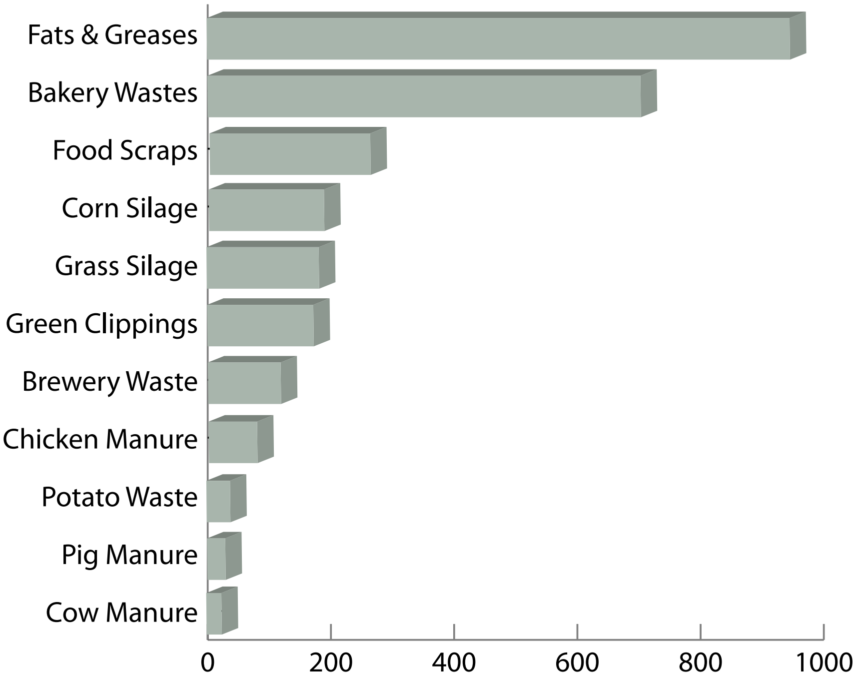
Figure 4. Midwestern Cattle Farms



Cattle Farms	IA	IL	IN	KS	MI	MN	MO	ND	NE	OH	SD	WI	Total
2500+	96	14	15	263	40	20	18	15	311	9	68	44	913
1000-2499	398	32	41	559	85	161	225	156	776	51	412	207	3103
500-999	1264	287	123	1270	271	620	684	543	1511	281	1355	652	8861

Source: USDA National Agricultural Statistics Service (NASS), 2007 Census of Agriculture

Figure 5. Biogas Generation Potential of Substrates



Cubic meters of biogas production per ton of substrate.

Source: Data derived from www.biogas-energy.com, © 2007 Biogas Energy, Inc., translated from: Basisdaten Biogas Deutschland, Marz 2005,: Fachagentur Nachwachsende Rohstoffe e.V.

Wastewater Treatment Facilities (WWTFs)

Potential sources for biogas production are all around us, from our landfills to our farms and food processing facilities. City sewers carrying household sewage and wastewater to treatment facilities hold another significant source of biogas production that could be converted into useable forms of energy. Wastewater treatment facilities in the U.S. use physical, chemical, and biological processes to remove contaminants from wastewater and household sewage. Treatment results in a liquid and solid waste stream that can either be reused or discharged.

WWTFs use one of three primary treatment methods to reduce the volume of waste and the number of contaminants: anaerobic digestion, aerobic digestion, and composting. According to the U.S. EPA, there were more than 16,000 municipal wastewater treatment

Project Highlight: Co-digestion at the Jer-Lindy Dairy

Anaerobic digesters have been synonymous with wastewater treatment plants and landfills, and have usually only been found at large livestock operations. This may no longer be the case. The Jer-Lindy Farm, located near Brooten, MN, is working to prove that digesters can work on average-sized Minnesota dairy farms. Jerry and Linda Jennissen's 240-acre dairy farm has 160 milking cows. The Jennissens, with the help of a grant from the Environment and Natural Resources Trust Fund, are testing cutting-edge technology to see if it might be feasible—or even profitable—for an average-sized Minnesota dairy farm to operate an anaerobic digester.

In the fall of 2007, construction started on the Jer-Lindy digester, and by May 2008 it began to produce electricity. The manure from the Jennissen's dairy cows is scraped twice daily into a mixing pit where recycled water is added in order to achieve 6 to 8 percent solids composition of the slurry, which is necessary to operate the system. The slurry is then pumped into the 33,000 gallon digester tank where it is held at 106 degrees for five days. The biogas collected from the digester is used in an internal combustion 350-horsepower Chevrolet engine to power an electrical generator that produces approximately 40 kilowatts of electricity. Excess electricity not used to power the digester plant is sold to Stearns Electric Association.

As a trial plot for average dairy farms, the Jennissens have learned many valuable lessons and paved the way for future projects. The project has not been without its challenges. The Jennissens discovered early on that the manure from their cows did not produce enough gas to utilize the full capacity of the engine. They partnered with a local dairy processing plant to add cheese whey to their digester, which tripled their gas production. The reliability of the engine generator set has also been an issue. The pilot site has gone through three engines because they have not found a small-scale engine designed to run on biogas long-term. The Jennissens have partnered with a local electrician to design an engine generator set capable of operating long-term and at the size needed for the project. The future of this project holds great potential for additional anaerobic digester projects in Minnesota and the Midwest.

Project Highlight: Co-digestion at Fergus Falls Wastewater Treatment Plant

The city of Fergus Falls, Minnesota has spent the last couple of years experimenting with anaerobic digestion at the city's wastewater treatment plant. The city started co-digesting the thick corn stillage syrup from the local ethanol plant in the facility's three digesters to increase biogas production. Each of the digesters has a capacity of 471,000 gallons. One digester has a stationary roof with the ability to capture 15,000 cubic feet of biogas, while the other two digesters have floating roofs, each collecting 7,500 cubic feet of biogas.

The plant processes 2.3 million gallons of wastewater per day and burns the biogas in a converted boiler to heat the digesters and the buildings at the facility during the winter. The boiler has the potential to process 50,000 cubic feet of biogas per day. Solely digesting wastewater produced 16,000 cubic feet daily, using only one-third of the boiler's potential. In order to increase biogas production, the plant conducted a study on co-digestion of stillage syrup. The study demonstrated that a significant increase could be achieved; biogas production would double and the methane content of the biogas would average 65 percent. The increased methane content could be attributed to the high levels of protein and fats in the ethanol syrup feedstock.

The addition of syrup has created enough biogas to satisfy the daily requirements for heating the facility in the winter and has had a significant economic impact, allowing the city to save more than $4,000 a month on heating costs in the winter season. From 2008 to 2009, plant production tripled from 2,100,000 cubic feet to 6,200,000 cubic feet. During the same time period, natural gas bills have dropped by 80 percent--from $54,000 to $11,000.

facilities (WWTFs) nationwide in 2007. Only 544 facilities were utilizing anaerobic digestion technology, and only 106 WWTFs using anaerobic digestion were using the biogas to produce electricity and/or thermal energy (EPA, 2007).

Wastewater treatment facilities are large consumers of energy, and if facilities are able to capture biogas and convert the gas into electricity and/or heat, treatment plants could offset their own energy use. Co-digestion of multiple substrates began in Europe at wastewater treatment facilities that did not have enough material to use the full capacity of installed energy recovery systems. Europeans found that by adding additional organic feedstocks, they could produce more gas without additional technology investment. The project highlight, *Co-digestion at Fergus Falls Wastewater Treatment Plant* demonstrates the incredible energy potential and cost savings associated with an energy recovery system at a WWTF that brings in additional substrates. As evidenced by the EPA numbers, there is an enormous amount of energy potential to be captured each time we flush our toilets or drain our dishwater.

Federal & State Policy Background

The current policy environment at the state and federal level does not recognize the tremendous resource potential from biogas. Without additional mechanisms and incentives geared towards diverse biogas utilizations and expanded ownership or management models, biogas development will struggle to grow and an opportunity will be missed to diversify our energy supply with a stable and versatile renewable resource.

A tremendous amount of innovation has taken place in the biogas industry in the last several years. New biogas technology applications and end uses present real opportunities for additional resource development. The next section of this report examines the current policy mechanisms and structures that have supported biogas development and provides examples of policies tailored specifically for biogas.

Federal Policy

Federal legislation can have a significant impact on state and local policy and in turn, states can design policies to complement federal efforts or take action in an area not addressed by the federal government. Federal policy can provide a broad set of goals and objectives for the entire nation, but state and local agencies must determine the appropriate path for implementation. Federal support for biogas projects has consisted of grants, loans, production incentives, research funding, feasibility study assistance, and broad resource mandates. This section will discuss production incentives, broad climate and energy policy and federal regulatory actions. Discussion of grants and loans is reserved for the **Biogas Policies for Consideration** section of this report, as these have been some of the most effective policy mechanisms to help build individual biogas projects.

Production Incentives

Historically, the offering of production incentives, particularly tax credits, has been the policy instrument of choice to spur renewable energy development. These incentives are crafted to entice renewable energy equity investors. Because of a high level of corporate investment, wind energy projects have been able to take full advantage of federal tax credits. Biogas projects have also had success leveraging federal tax credits to construct projects, but individual on-farm systems have utilized federal grants and loans instead of tax credits as a majority of farm owners do not have enough passive income to qualify for the credits.

Tax credits are an attractive policy mechanism for biogas projects because they may provide an additional incentive for ownership and management models beyond individual farm ownership and also provide an incentive for industrial or municipal systems. Tax credits will continue to be an important financing mechanism for biogas projects in the future as large-scale and industrial biogas projects are constructed. The existing production incentives are geared toward electricity production and do not currently allow for advanced utilization options, such as renewable gas or thermal applications, to qualify for the incentives. Expanding incentive program definitions to allow additional utilizations of biogas could spur additional project development.

The Production Tax Credit (PTC) is one of the most popular renewable energy tax credits. The PTC has been in operation since 1992 with intermittent periods of availability that depend upon Congressional action. Renewable energy development ramps up when the credit is available and grinds to a halt when the credit expires. The PTC is a ten-year per-kilowatt-hour tax credit for qualified renewable energy resources, including landfill gas, anaerobic digestion, and closed- and open-loop biomass facilities. The 2009 American Recovery and Reinvestment Act (ARRA) revised the PTC by extending the in-service deadline by three years for a majority of qualified renewable energy technologies and allows qualified facilities to take advantage of the Business Energy Investment Tax Credit (ITC) or take it alternatively as a cash grant from the U.S. Department of Treasury (DSIRE, 2010d).

The Business Energy Investment Tax Credit (ITC) is similar to the PTC but has traditionally provided tax credits for solar power, fuel cells, small wind systems, geothermal energy, microturbines, and combined heat and power facilities. Instead of providing a per-kilowatt-hour credit, a percentage tax credit based on qualifying costs has been available. The 2009 ARRA changed the ITC to allow PTC eligible facilities, including closed- and open-loop biomass facilities, to qualify for a 30 percent tax credit through 2013. Prior to this change closed-and-open-loop biomass facilities were not eligible for the ITC. New facilities take advantage of the ITC or a cash grant from the U.S. Department of Treasury (described below) if construction begins in 2010. This change to the ITC allows biogas projects, generally classified as open-loop biomass facilities, to use the ITC to help finance projects over the long-term.

A grant program (Section 1603) of the U.S. Department of Treasury was included as part of the 2009 ARRA and provides up to 30 percent of construction and installation costs for a depreciable or amortizable renewable energy facility in lieu of tax credits. Facilities can take advantage of either the cash grant or the ITC. This grant is available to facilities placed in service or beginning construction in 2009 or 2010. The current program excludes open-loop biomass facilities that have a nameplate capacity rating of 150 kilowatts or less. A proposal by U.S. Senators Diane Feinstein (D-Calif.) and Jeff Merkley (D-Ore.) would extend the grant program until 2012. The bill needs Congressional action in order to extend the program and, at time of publication, no action has been taken.

The creation or extension of these production incentives or cash grant programs gives biogas project developers financing structure options for the project, but more choices can also create confusion. The Lawrence Berkeley National Laboratory and the National Renewable Energy Laboratory (NREL) conducted a quantitative analysis and considered qualitative factors of the PTC, ITC and the U.S. Treasury cash grant program. Results were presented in the report, "PTC, ITC, or Cash Grant? An Analysis of the Choice Facing Renewable Energy Power Projects in the United States," which concluded that, based on quantitative factors, open-loop biomass projects would receive more value from the ITC rather than the PTC. Qualitative considerations, such as no performance risk, more immediate use of tax base, and no power sale requirement, gave the edge to closed-loop biomass projects utilization of the PTC. Quantitative analysis alone could not conclusively determine if closed-loop biomass projects would fare better under the PTC or ITC. Combining the qualitative and quantitative factors analyzed, open- and closed-loop biomass would receive a greater benefit utilizing the ITC (Bolinger et al., 2009).

Although existing tax credits have provided some incentives for biogas projects, a federally dedicated production incentive for biogas does not currently exist. In an effort to level the playing field among renewable energy incentives, Senator Ben Nelson of Nebraska introduced the Biogas Production

Swine Project Highlight: O'Lean Energy, Dodge, Nebraska

Danny and Josie Kluthe's neighbors were pleasantly surprised when the Kluthes were able to double the size of their hog operation while dramatically reducing the smell of the hog manure. The Kluthes were able to achive this goal thanks to their anaerobic digester. The complete mix digester system is an in-ground concrete tank with an insulated flexible cover that stores all the manure from the 8,000 head of swine on the Kluthe Farm near Dodge, Nebraska.

The Kluthe's number one goal with the installation of the digester was to reduce the odor from their operation. The Kluthes created Olean Energy to sell the electricity from their digester to the Nebraska Public Power District (NPPD). The farm produces and sells 549,000 kilowatt hours - enough to power 65 homes for one year -under a buy-all, sell-all contract. Olean Energy sells the electricity produced to the power company at a wholesale rate and purchases it back off the grid at retail rates.

Nebraska's first methane-powered electrical energy production project got off the ground with the financial support of a $200,000 grant from the Nebraska Environmental Trust and an $80,000 grant from USDA Rural Development. Nebraska's first methane-powered electrical generator has reduced greenhouse gas emissions by 4,878 metric tons of CO_2 on an equivalent basis per year. Besides the amazing environmental benefits, the Kluthe Farm digester has reduced odor, created nutrient-rich fertilizer, and provided consistent income amidst volatile hog market prices.

Incentive Act of 2009 (S. 306). The legislation, if passed, would provide a $4.27 tax credit for every million British thermal units (BTUs) of biogas produced. Biogas is defined as gas derived from the processing of a qualified energy feedstock, such as livestock manure, or organic agricultural or food industry byproduct. The legislation specifies the gas must contain at least 50% methane (Thomas, 2010a). The bill currently has 14 co-sponsors, including Democrats and Republicans from across the United States. A companion bill (H.R. 1158) has also been introduced in the House of Representatives by Representative Brian Higgins of New York. The Higgins companion bill has 27 co-sponsors. Both bills have been referred to the appropriate committees and no action has been taken to date.

H.R. 5581 was introduced by U.S. Representative Kind on June 23, 2010. This proposed legislation presents an opportunity to create a financial incentive for biogas projects producing biomethane to be used as a replacement for natural gas or compressed and used as a vehicle fuel to further diversify the utilization of biogas produced from agricultural livestock manure and processing byproducts. The legislation proposes to amend the Internal Revenue Code for a qualified biogas facility to use clean renewable energy bonds to finance a project. Eligible projects could receive a 30 percent credit. Biogas produced from eligible facilities must be at least 52 percent methane. Biogas projects producing electricity from biogas would not qualify (Thomas, 2010b). The bill also directs the NREL to conduct a biogas study that would examine biogas quality, methods for maximizing energy content, and recommendations for production expansion (Biomass Intel, 2010).

Climate and Energy Policy

The climate and energy debate has received an unprecedented amount of time and attention during the 111th Congress. The U.S. House of Representatives passed the American Clean Energy Security Act (ACES) in June 2009. The legislation represents the first time either federal legislative body has passed legislation aiming to limit the amount of carbon emissions across the economy. Progress has been slower in the Senate, but proposals to address greenhouse gas emissions have emerged. The Senate Energy and Natural Resources committee passed an energy bill out of committee in 2009, but no action has been taken on the Senate floor. The possibility of passing an energy or climate policy or some combination thereof is unclear at time of publication and the prospects for passing a climate policy in the Senate by the end of 2010 are dim. This section summarizes current Senate proposals, the House passed bill and discusses carbon offsets, which present an economic opportunity for biogas projects.

The American Clean Energy Leadership Act (ACELA) was passed out of the Senate Energy Natural Resources committee in June 2009. The bill includes several measures addressing renewable energy production, energy efficiency, transmission infrastructure, traditional energy production, and workforce development. A few notable provisions from the bill for biogas projects include setting a national Renewable Electricity Standard (RES) of 15 percent by 2021 and the creation of a "Clean Energy Investment Fund" to be administered by a new agency within the Department of Energy, the Clean Energy Deployment Administration (CEDA). The bill also includes a provision for the Federal Energy Regulatory Commission to establish a national interconnection standard for small power production facilities, 15 kW or less (U.S. Senate, 2010). Although the national interconnection standard would not be applicable for biogas systems, it would establish a precedent for creating national standards for future distributed generation resources at a larger scale.

Poultry Project Highlight: Wenning Poultry Farm, Fort Recovery, Ohio

Currently in the U.S, there are three poultry farms operating digesters that prevent the release of 29,000 metric tons of methane - a greenhouse gas 23 times more potent than carbon dioxide,-into the atmosphere annually. Wenning Poultry, outside of Fort Recovery in western Ohio, was the first large-scale U.S egg producer to use biogas to generate power. Jim Wenning, who heads the family business, entered into agreements with Buckeye Power, Inc. and Midwest Electric, Inc to sell the electrical power generated from biogas created on the poultry farm.

The 600,000 chicken operation produces more than 25 tons of litter daily, which powers three Martin Machinery packaged 600-kilowatt generator sets for a maximum output of 1.8 MW. The digester system was designed by GHD, Inc.--a mesophilic digester that keeps the poultry litter at 100-105°F during a 21-30 day digestion process. The digester is buried below ground and the containment vessel is insulated to prevent heat loss.

Wenning's system is connected to the Midwest Electric distribution system; all the electrical output flows through a meter and is purchased by Buckeye Power. Midwest Electric has a three-phase circuit in close proximity, avoiding the need to make upgrade investments for interconnection.

The project costfor Wenning Poultry Farm biogas digester was $2 million, $500,000 of which was provided by a USDA grant. Jim Wenning projects a seven-year investment recovery period for the biogas system. The farm has plans to construct a new laying house to increase the total number of hens to more than one million.

Table 1. Summary of Federal Energy and Climate Proposals

Policy Proposal	Status	Key Provisions	Implications for Biogas Projects
U.S. House of Representatives: American Clean Energy Security Act (ACES) Authors: Rep. Henry Waxman (D-CA) and Rep. Edward Markey (D-MA)	Passed by floor vote, awaiting action in the Senate	80% reduction in greenhouse gas emissions below 2005 levels by 2050 Renewable Electricity Standard (RES) of 20% by 2020	Opportunity to sell carbon credits from avoided methane emissions from biogas projects Biogas-to-electricity projects to help meet RES
U.S. Senate: American Clean Energy Leadership Act (ACELA) Author: Sen. Jeff Bingaman (D-NM)	Passed by Energy Natural Resources committee, awaiting floor action	Renewable Electricity Standard (RES) of 15% by 2021 Proposes to create a "Clean Energy Investment Fund" Creation of a national interconnection standard	Biogas-to-electricity projects to help meet RES Possible capital project assistance available Creates a model for national interconnection standards
U.S. Senate: American Power Act Authors: Sen. John Kerry (D-MA) and Sen. Joe Lieberman (I-CT)	Introduced, no committee or floor action has taken place	80% reduction in greenhouse gas emissions below 2005 levels by 2050	Opportunity to sell carbon credits from avoided methane emissions from biogas projects

Also in June 2009, the U.S. House of Representatives passed the ACES Act. The ACES bill contains several similar provisions to the Senate ACELA bill, but also includes an economy-wide greenhouse gas reduction schedule. The ACES Act emerged from the Energy and Commerce committee as a sweeping piece of energy and climate legislation. The bill calls for an 80 percent reduction in greenhouse gas emissions below 2005 levels by 2050. The bill proposes to put in place a cap-and-trade program, a market mechanism which would issue allowable amounts of greenhouse gas emissions to covered entities. Covered entities producing fewer emissions than the allowable cap would be eligible to trade or sell extra allowances to other covered entities. Agriculture is not one of the covered entities required to meet greenhouse gas reductions. Instead, agriculture is able to generate carbon offsets to assist covered entities in achieving compliance. Covered entities are able to use up to 2 billion tons of offset credits to satisfy compliance obligations (PEW, 2010). This creates a tremendous opportunity for agriculture, specifically biogas projects. As profiled in the project highlight, *Haubenschild Farms, Biogas Pioneers*, agriculture- based biogas projects can generate carbon credits, a verifiable and tradable commodity that places a value on methane emission reductions and provides an additional revenue source for the project. A mandatory carbon market would likely ensure a higher carbon credit price, thereby improving project financing and bringing more projects online. Since carbon credits are based on methane capture and destruction, the incentive would not be tied to biogas utilization, as is the case for other existing financial incentives.

The ACES Act gives authority to the United States Department of Agriculture (USDA) to certify and verify agricultural and forestry offsets. USDA is directed to establish rules for an offset program, including methodologies to account for greenhouse gas benefits, activity baselines, and leakage, as well as third-party verification, reporting and record-keeping requirements, project plans, certification and implementation, one year from adoption (PEW, 2010). Biogas capture and combustion is included in a list of eligible offset practices, creating the opportunity for biogas projects to trade offset credits to covered entities and provide an additional source of project income. A mandatory carbon market would provide a greater economic incentive for biogas projects compared to the experience of a voluntary carbon market, through programs such as the Climate Action Reserve, the Voluntary Carbon Standard, the American Carbon Registry, or the Chicago Climate Exchange.

If and when a climate bill is debated in the Senate, it will likely be a combination of the American Clean Energy Leadership Act (ACELA) passed by the Energy and Natural Resources committee and some or multiple elements from currently proposed bills addressing greenhouse gas emissions. Action in the Senate began in the fall of 2009 when

Senators Barbara Boxer (D-Calif.) and John Kerry (D-Mass.) introduced the Clean Energy Jobs and American Power Act (S.1733). The bill received little traction and in May 2010, Senators John Kerry (D-Mass.) and Joe Lieberman (I-Conn.) introduced the American Power Act (APA).

The American Power Act addresses domestic clean energy development, global warming pollution reduction, consumer protection, job protection and growth, international climate change activities, and community protection from global warming impacts (Kerry, 2010). APA is similar to the House-passed ACES Act in that it seeks to reduce greenhouse gas emissions, economy-wide, approximately 80 percent by 2050 through a cap-and-trade program and gives the authority for an agricultural offset program to the USDA, who is responsible for establishing standardized methodologies to determine additionality, establish activity baselines, measure performance, and account for and mitigate potential leakage (Kerry, 2010). No more than 2 billion tons of offset credits annually can be used by covered entities to achieve program compliance and of the total offsets allowed, no more than 75 percent can come from domestic offsets (Kelly, 2010). The current offset proposal in the American Power Act also closely follows the ACES Act.

At the time of publication, it was unclear if the Senate would take action on a comprehensive climate and energy bill prior to the end of the 2010 calendar year. Additional energy and climate proposals were in the development stages in the Senate while this report was written. In the absence of federal action, state and regional efforts are likely to take the place of a federal policy. In the **Biogas Policies for Consideration** section of this report, a federal cap on carbon emissions emerged as one of the most promising policies for biogas projects. The potential for biogas projects to generate carbon credits under a national cap-and-trade program presents significant economic opportunity, but it is difficult to estimate the exact impact without a policy in place. Additional discussion on the economic impact for agriculture under a federal carbon cap is discussed in the regulatory actions portion of this section.

Cattle Project Highlight: Amana Farms, Iowa

The Amana Colonies, a popular Iowa tourist destination, are no longer plagued by the odor from Amana Farms, Inc., a 2,400-head beef operation west of Amana. Amana Farms installed an anaerobic digester primarily to control odor. The digester also produces methane gas from the cattle manure and converts it to energy.

The combination plug-flow and complete-mix digester was designed by GHD, Inc of Chilton, WI. The 1.6 million gallon tank retains the feedstock for 21 days. The manure is collected by scraping the concrete floors of the cattle pens. The manure that goes into the digester only accounts for 20 percent of the total feedstock; the other 80 percent is made up of industrial and food processing waste from industries such as Genencor International, Cargill, and International Paper's Cedar River Mill in Cedar Rapids.

The $4.9 million facility produces enough biogas to power four 1057 HP electric generators, which produce up to 2.6 megawatts of power. This power provides 15 percent of Amana Service Company's base load electricity during the winter and 10 percent during the summer months. The Amana Farms Inc. anaerobic digester project received $1.08 million in funding from the Iowa Power Fund board and $500,000 from USDA Rural Development. The Amana Society Inc. contributed $3.5 million to the project. Approximately $165,000 of the Power Fund allotment is dedicated toward an educational component

The digestate is used as fertilizer on the over 7,000 crop acres Amana owns. More than $300,000 in cost savings is being passed onto Amana Utility residential and industry customers, such as Whirlpool Amana. The digester has reduced greenhouse gas emissions by 5,879 metric tons of CO_2 on an equivalent basis per year.

Dairy Project Highlight: Five Star Dairy, Elk Mound, Wisconsin

"It's hard to put a value on that," says Five Star Dairy owner Lee Jensen of his anaerobic digester located near Elk Mound, Wisconsin. Lee and his cousin Jim Jensen bought the farm from their parents and built Five Star Dairy in 2000. Today, the farm has more than 1,000 registered milk cows and 900 registered heifers, and the Jensens' are producing 775 kilowatts of energy from their herd's manure.

What is unique about the Five Star Dairy is the involvement of the three entities working together to create electricity. With support from a $180,000 USDA grant, Microgy, Inc., Dairyland Power Cooperative, and Five Star Dairyformed a unique partnership agreement as the first Midwestern on-farm biogas project that uses efficient Danish technology to produce five times morebiogas than other systems. Microgy designed and built the digester equipment, including the 50-foot digester tank and the 20,000 gallon substrate co-digestion product tank. To fill this tank, Five Star Dairy uses six semi truck loads of used cooking oil, animal fats, and greases shipped in from various locations each week. Microgy is responsible for operating and maintaining the digester even though Five Star Dairy owns the equipment and the methane gas, which is then sold to Dairyland Power Cooperative. Dairyland owns and operates the generator, which delivers 775 kilowatts to the electric grid, enough to power approximately 600 homes.

The anaerobic digester at Five Star Dairy provides additional farm income and Dairyland Power Cooperative customers with reliable renewable energy. The digester has also reduced the amount of odor, pathogens and weed seed in the manure. Five Star Dairy says their milk production is the highest it has ever been since they started using the digested solids as bedding. While other factors may contribute to increased milk production, Five Star Dairy has also documented a reduction of hock abrasions and observed more comfortable rest for the cows. All of these individual factors combine to make the anaerobic digester system a worthwhile investment for the farm.

Regulatory Actions

Federal regulatory agencies have significant influence over the implementation of Congressional policies aimed at the state or local level. Once a proposed piece of legislation becomes law, it becomes the responsibility of a federal agency to create the administrative rules that will guide implementation. The rulemaking process of public policy formulation gives the public an opportunity to weigh-in on policy implementation by providing comments for consideration by regulators. These comments are taken into account when determining final rules for a specific program.

The National Environmental Policy Act (NEPA) of 1970 created the Environmental Protection Agency (EPA). EPA is responsible for implementing policy related to the enhancement or protection of air, water, and land in the United States. Biogas projects intersect with EPA regulations for both air and water quality. The Clean Air Act, originally passed in 1970 and amended multiple times since then, gives EPA the authority to administer air quality regulation programs. The Clean Water Act, first passed in 1972 and amended several times, give EPA the authority to administer water quality regulation programs. This section describes current EPA actions under these two broad pieces of legislation that will have an impact on future biogas development.

Clean Air Regulation

While Congress has yet to take legislative action to regulate greenhouse gases, a 2007 Supreme Court decision gave EPA the "authority" and "obligation" to regulate greenhouse gases under the Clean Air Act. The Court decision in Massachusetts v. Environmental Protection Agency found that greenhouse gases are air pollutants covered by the Clean Air Act and EPA must determine if they pose a danger to public health or welfare or if science is too uncertain to make a determination (EPA, 2010d). The decision gave authority to EPA to regulate greenhouse gas emissions under the Clean Air Act, an existing statutory requirement to protect and improve U.S. air quality. This court decision is adding pressure to Congress to pass legislation regulating carbon emissions; a flip from historical public policy setting that requires policy passage to determine regulatory authority. This decision set in motion an agency effort to regulate greenhouse gas emissions under the Clean Air Act. Under the Bush administration, EPA drafted a proposed endangerment finding for interagency review, issued an Advance Notice of Proposed Rulemaking (ANPR), and took public comments for 120 days (EPA, 2010d). EPA actions under the Obama administration have included publishing a proposed Endangerment and Cause or Contribute Finding for greenhouse gases in the Federal Register. The EPA accepted public comment and issued a final Endangerment and Cause or Contribute Finding, which has been signed by EPA Administrator Lisa Jackson (EPA, 2010d).

The final Endangerment and Cause or Contribute Finding does not place specific requirements on industry, but establishes a path for EPA to finalize proposed greenhouse gas emissions requirements for light-duty vehicles in conjunction with Corporate Average Fuel Economy (CAFE) standards (EPA, 2010d). However, EPA determined at the end of

Project Highlight: Haubenschild Farms, Biogas Pioneers

A pioneer in on-farm anaerobic digestion, Haubenschild Farms, was selected as an AgSTAR "Charter Farm" to demonstrate farm-scale anaerobic digestion technology in 1999. The family-owned 1,000-acre farm near Princeton, Minnesota, was one of twelve farms selected nationwide to receive a grant of $127,500 from AgSTAR, along with a $150,000 six-year zero interest loan from the Minnesota Department of Agriculture, for the construction cost of the digester and generator system. Completed in October 1999, the digester is a 350,000 gallon in-ground plug-flow concrete tank which processes manure from 900 milking cows and produces approximately 3,000 kilowatt hours of electricity per day.

The Haubenschild project was one of the first 'on-farm digesters' and helped lead the way in two other important areas: hydrogen fuel cells and trading carbon credits. In 2005, a portion of the biogas generated was use to run a hydrogen fuel cell. In the fall of 2006, the Haubenschilds were the first farm to begin trading carbon credits from the methane captured by their anaerobic digester. The carbon credits are calculated based on the amount of methane during the anaerobic digestion process, rather than released from manure storage facilities. The credits were certified and sold on the Chicago Climate Exchange.

Haubenschild Farms are innovators in the biogas industry. From producing enough electricity from their manure to save $40,000 a year on their electricity bills and power 75 additional homes, to being credited for capturing 525 tons of methane or 9,587 metric tons of carbon dioxide equivalent in just two and a half years, Haubenschild Farms are at the leading edge of renewable energy technology.

2009 that, if it was to proceed with regulating greenhouse gas emissions for vehicles, then other Clean Air Act requirements would require regulation of stationary sources, including agricultural operations and related industries. In order to reduce the potentially significant administrative burden for regulating small and large stationary sources of greenhouse gas emissions, the EPA issued a final "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule" in May, 2010, also known as the "tailoring rule." The final rule tailors Clean Air Act requirements for permits under the New Source Review Prevention of Significant Deterioration (PSD) and Title V Operating Permits for new and existing facilities (EPA, 2010c).

The tailoring rule puts in place a three-step process for EPA to regulate stationary sources of greenhouse gas emissions. Possible implications for agricultural operations and related industries are covered under step three and would not be impacted by the first two steps. EPA estimates that facilities responsible for almost 70 percent of total national greenhouse gas emissions will be covered under the tailoring rule. Agriculture, livestock operations, and large biofuels producers could possibly be impacted under step three (Harsch, 2010).

The tailoring rule does not exclude emissions from biomass combustion or from biogenic sources from permitting requirements (Harsch, 2010). The regulatory requirements for biomass combustion will need to be resolved. Although agriculture operations and most related industries will not be subject to the EPA permitting requirements under the Clean Air Act in the near term, biogas projects still stand to greatly benefit from a legislative carbon regulation program where methane capture and destruction projects can sell carbon credits to covered entities.

Table 2. EPA Timeline for Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule

Step One	**Jan. 2 - June 30, 2011**	**Only facilities currently subject to the PSD permitting program will be subject to greenhouse gas emissions permitting**
Step Two	**July 1, 2011 - June 30, 2013**	**Builds on step one** **Covers new projects that emit at least 100,000 tons of greenhouse gas emissions per year**
Step Three	**2011 - July 1, 2012**	**Considers whether certain smaller sources should be permanently excluded from permitting requirements** **Determines strategies to streamline requirements** **Sources with greenhouse gas emissions below 50,000 tons per year will not be subject to permitting requirements** **No action will take place before April 30, 2016**

Source: U.S. Environmental Protection Agency. Prevention of Significant Deterioration, and Title V Greenhouse Gas Tailoring Rule. Factsheet. www.epa.gov/nsr/documents/20100413fs.pdf, accessed June 29, 2010c.

could decline by as much as 7.2 percent from baseline levels (USDA, 2009). However, other studies which have taken into account changes to production managementpractices and conversion to bioenergy crops show increases to net farm income of more than 2.9 percent by 2045 (USDA, 2009). The analysis also concluded that net revenue from offsets could overtake any net costs to agriculture (USDA, 2009).

Economic Impacts: Agriculture and Carbon Regulation

The flurry of activity by the EPA and Congress has prompted multiple collaborative studies to conduct analysis on possible implications from climate and energy policy on different sectors of the economy. Select studies have examined agriculture specifically, including the livestock sector. Although each of the studies summarized below use different economic models and assumptions, each study stresses the importance of carbon credit availability for agriculture in order to provide an additional source of revenue for agricultural operations. The sale of carbon credits by agricultural producers to covered entities under a cap-and-trade program could compensate producers who are likely to be faced with increased input costs. However, it is difficult to predict the exact economic impacts on agriculture until a program is adopted.

In the first month after passage of H.R. 2454, the ACES Act, USDA conducted a preliminary analysis on the legislation's effects on agriculture. The USDA analysis was based on energy price effects estimated by EPA. USDA used the Food and Agricultural Policy Simulator (FAPSIM) to model agricultural impacts. The USDA analysis concluded net farm income

A second analysis, also using EPA energy price effects, conducted by the Agricultural and Food Policy Center (AFPC) at Texas A & M University in August 2009, used the Farm Level Income and Policy Simulation Model (FLIPSIM) and 98 representative crop and livestock producers to assess overall economic impacts from H.R. 2454 (Golden et al, 2009). AFPC analyzed four different scenarios for representative farms: baseline; cap-and-trade without carbon credits; cap-and-trade with carbon credits; and cap-and-trade with carbon credits and saturation. The analysis concluded that almost all crop and dairy farms examined will have higher average annual cash receipts under cap-and-trade scenarios due to higher prices, but dairy farms will experience lower net cash farm income under the cap-and-trade alternatives (Outlaw et al, 2009). Although the AFPC analysis only examines representative farms across the U.S. and not agriculture as a whole, the economic scope and factors examined are very complete (Golden et al, 2009).

A third analysis conducted by the Nicholas Institute for Environmental Policy Solutions (NIEPS) at Duke University used the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG). The analysis showed that while agricultural producers will see price increases from fossil fuel intensive input suppliers, new revenue opportunities for bioenergy feedstocks and carbon credits could outweigh increased costs (Baker et al, 2009). The NIEPS analysis included a baseline scenario but also three alternative carbon price scenarios of \$15, \$30, and \$50 a ton of CO2e.

A fourth analysis conducted by the Bio-based Energy Analysis Group (BEAG) at University of Tennessee (conducted on behalf of the 25x'25 coalition) examined different carbon credit market scenarios. In addition to a baseline scenario, the study also includes a scenario for EPA only greenhouse gas regulation, a limited offsets scenario, a multiple offsets scenarios, and a multiple offsets scenario requiring carbon neutral residue harvest. BEAG used the agricultural policy simulation model POLYSYS (de la Torre et al, 2009). The BEAG analysis was one of the few studies that separated livestock sector impacts from crop and forestry impacts. Net returns of carbon credits from hogs are projected to exceed \$120 million by 2025 and \$208 million for dairy by 2025 (de la Torre et al, 2009). The net return estimates are highly dependent on how a final cap-and-trade policy is structured.

Although each of the economic studies developed a unique set of baseline

scenarios and analysis scenarios, a common thread in the analyses is that agriculture will need to generate carbon offset revenues in order to cope with possible increased input costs and decreased revenue. The long-term outlook for how a carbon regulation policy will impact agriculture will depend on how the final program is structured.

Clean Water Regulation

Since the industrial revolution and the migration of people moving from rural areas into expanding cities, agricultural operations have been growing in size to sustain food and fiber production for a growing population. Shrinking profit margins, increasing returns to scale, and large social and economic factors have increased concentration of livestock production in the United States. These trends have also occurred in other industries, leading Congress to enact stricter regulations to enhance and protect water quality. The Clean Water Act, first passed in 1972 and amended in 1977 and 1987, is the primary U.S. law governing water pollution. Within the Clean Water Act, large farms also known as Confined Animal Feeding Operations (CAFOs) are identified as a source of water pollution and are subject to permitting requirements (Wyant, 2010). CAFOs that discharge or propose to discharge are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit (EPA, 2010a). Other large industrial or municipal facilities that could be capable of producing biogas, such as wastewater treatment facilities, are also required to obtain NPDES permits under the Clean Water Act. Stricter Clean Water Act permitting regulations could drive development of biogas projects as a way to manage waste streams and alleviate regulatory burdens.

The Environmental Protection Agency (EPA) works in cooperation with state permitting authorities to implement and ensure compliance with Clean Water Act rules. The EPA and USDA also collaborate at the federal level to guide implementation of CAFO rules and permitting requirements. A 2009 lawsuit filed by the Natural Resources Defense Council, Waterkeepers Alliance, and the Sierra Club challenged the 2008 CAFO permitting rule. EPA reached a settlement agreement with the environmental groups in 2010. The settlement agreement may have major implications for future CAFO regulation. The agreement calls for EPA to propose a new rule by May 26, 2011. This rule will require all CAFOs to submit information about their operations including operation location or location of operation owner, the animal population, manure storage, land application practices, manure handling outside of the operation, and if an NPDES permit has previously been issued to the operation (Schuff, 2010). EPA will be accepting public comments on the types of information EPA should or should not collect as part of the revised CAFO rule. Ultimately, depending on the structure of the revised CAFO rule, biogas development on livestock operations could be a strategy or best practice for manure management.

State Policy

Midwestern states have implemented several important pieces of legislation that have helped to foster the development of the region's renewable energy resources and build a sustainable renewable energy industry. The majority of public policy efforts in Midwestern states have been focused on wind development, but in states where the wind resource is not as large, developing biomass resources has also been a key focus. State-level policies take the form of renewable energy requirements, net metering, production incentives, voluntary feed-in tariffs or standard-offer contracts and green power purchasing. Existing state policy

Project highlight: Central Vermont Public Service Cow Power™

The state of Vermont is making headlines due to Central Vermont Public Service's (CVPS) leadership in a green power purchasing program. CVPS serves approximately 158,000 retail customers across the state of Vermont and has created a program known as "CVPS Cow Power™." The CVPS's Cow Power™ program was the first manure-based, farm-to-consumer green power purchasing program in the U.S. Customers who sign-up to participate receive all, half, or a quarter of their energy through the program, which supports renewable energy development and Vermont dairy farms. CVPS utility consumers who opt into the program pay a 4-cent premium per kWh which is paid 100 percent to Cow Power producing farms. CVPS Cow Power™ energy is currently supplied by six Vermont dairy farms utilizing anaerobic digestion technology to produce electricity.

CVPS Cow Power™ farms have at least 500 cows and produced between 0.79 and 3.3 million kilowatt-hours of electricity in calendar year 2009. Vermont dairy farmers are realizing several benefits of the CVPS Cow Power™ program. Farmers are able to rely on a consistent new source of revenue from electricity sales to CVPS customers. One of the largest benefits for participating farmers is the odor reduction of the digested manure when it is spread as a fertilizer. Another benefit is the utilization of digested separated solids which are used as an alternative to sawdust bedding for the cows and have saved farms between $60,000 and $150,000 in 2009 where the market price for kiln dried sawdust reached $2,300 per load.

Since the CVPS Cow Power™ program's inception in 2004, a total of 53 million kWh's have been sold to customers participating in the program. CVPS hopes to keep customer demand leading farmer supply of energy to boost farmer and lender confidence that consumers will pay a premium for renewable energy from farm projects. CVPS also hopes to encourage enough farm projects to meet five percent of the state's energy needs with biogas over the next 10 years.

The Cow Power program also hired a full-time project coordinator to help dairy farmers guide their digester projects through the many permitting, grant applications, construction, and other logistic hurdles. All of the farms have also received cash grants to help defray some or all of the interconnection project costs.

A 2009 amendment to Vermont's Sustainably Priced Energy Development Program (SPEED) (originally passed in 2005) set a standard offer rate for farm methane producers to receive 16-cents a kilowatt hour. The rate was designed to help jump-start development of additional farm-generated electricity projects, in addition to other renewable projects. The existing six projects noted above have been grandfathered into the SPEED Program and offered a 14.1 cent per kilowatt hour rate for the energy they generate in addition to the Cow Power premium.

CVPS Cow Power™ Participating Farms

Farm Name	Herd Size/Annual Milk Production	2009 Electricity Production
Audet's Cow Power LLC	**1,100 milking cows/25 million pounds**	**1.6 million kilowatt hours**
Green Mountain Dairy Inc.	**950 milking cows/21 million pounds**	**1.9 million kilowatt hours**
David and Cathy Montagne Farm	**600 milking cows/15 million pounds**	**1.0 million kilowatt hours**
Berkshire Cow Power LLC	**1,500 milking cows/40 million pounds**	**3.3 million kilowatt hours**
Maxwell's Neighborhood Energy LLC	**750 milking cows/18 million pounds**	**1.2 million kilowatt hours**
Gervais Family Farm, Inc.	**1,100 cows**	**790,000 excess kilowatt hours, half of the production offsets farm energy use**

incentives focus on electricity utilization from produced biogas. New biogas utilizations are supplying a source of renewable natural gas that can either be upgraded and injected into the existing natural gas pipeline distribution infrastructure or compressed and used as a transportation fuel. Although there are no existing state policy incentives or mechanisms geared toward renewable natural gas, the **Biogas Policies for Consideration** section of this report includes recommendations that states may consider to further develop renewable natural gas utilizations. This section details existing Midwestern states' efforts to expand renewable energy development and profiles state efforts outside of the Midwest that have contributed to biogas project growth.

Renewable Energy Requirements

The prevailing policy of choice to drive renewable energy development has been a Renewable Portfolio Standard (RPS) or some form of a renewable energy requirement. An RPS sets a percentage of electricity generation in an electric utility's portfolio to come from renewable energy resources by a certain date. An RPS starts out small in the near-term and steadily increases the percentage of renewable energy into the portfolio over time.

States began to take the lead on adopting individual requirements when the federal government failed to act on a national requirement for renewable energy. Generally, allowable resources used to meet a renewable energy standard, goal or objective include solar, landfill gas, wind, biomass, hydroelectric, municipal solid waste, hydrogen, and anaerobic digestion. It is up to the applicable sector to determine which renewable energy resources (with the exception of carve-outs or set-asides, discussed in the next section) will be used to meet the standard. Applicable sectors need to take into account cost, technical feasibility, and delivery mechanisms to bring the resource to market.

Renewable resources used to meet an RPS or objective might have small variations from state to state. Nationwide, 29 states and the District of Columbia have adopted an RPS and an additional six states have renewable energy goals. Table 3 below summarizes state level renewable energy standards, goals or objectives in the Midwestern footprint.

Renewable Energy Carve-outs or Set-asides

Within an RPS policy, states can choose to carve-out or set-aside a specific percentage of renewable energy generation to be derived from a specific renewable technology. Less than a handful of states within the Midwest have a resource carve-out as part of an RPS and those carve-outs are directed toward solar and wind energy or allow applicable sectors to meet part of the standard with energy efficiency savings.

Table 3. Summary of State Level Renewable Energy Requirements

State	Renewable Portfolio Standard (RPS)	Applicable Sectors
Illinois	25% by compliance year 2024-2025	Investor-Owned Utilities and Retail Suppliers
Indiana	---------	
Iowa	105 MW of renewable generating capacity	Investor-Owned Utilities
Kansas	20% of peak demand capacity by 2020	Investor-Owned Utilities and certain Rural Electric Cooperatives
Michigan	• All utilities: 10% by 2015 • Detroit Edison: 300 MW of new renewable by 2013 and 600 MW by 2015 • Consumers Energy: 200 MW of new renewables by 2013 and 500 MW by 2015	Municipal Utilities, Investor-Owned Utilities, Rural Electric Cooperatives and Retail Suppliers
Minnesota	• Xcel Energy: 30% by 2020 • Other utilities: 25% by 2025	Municipal Utilities, Investor-Owned Utilities and Rural Electric Cooperatives
Missouri	15% by 2021	Investor-Owned Utilities
Nebraska	---------	
North Dakota	Goal: 10% by 2015	Municipal Utilities, Investor-Owned Utilities and Rural Electric Cooperatives
Ohio	25% alternative energy resources by 2025	Investor-Owned Utilities and Retail Suppliers
South Dakota	Goal: 10% by 2015	Municipal Utilities, Investor-Owned Utilities and Rural Electric Cooperatives
Wisconsin	Statewide target of 10% by 2015; Statutory requirement varies by utility	Municipal Utilities, Investor-Owned Utilities and Rural Electric Cooperatives

Source: Information included in this table was collected from the Database of State Incentives for Renewables and Efficiency (DSIRE). Visit www.dsireusa.org for more detail on any of the above RPSs.

New York State has adopted, and is implementing, a tier-based RPS. New York State will use a combination of existing renewable energy resources and new renewable resources brought online through a Main Tier or a Customer-Sited Tier to reach a 30 percent RPS by 2015. Approximately 21 percent of the RPS target will be derived from existing renewable energy facilities; a small increment will be met through voluntary green power sales (DSIRE, 2010c). The remaining portion of the RPS target, which represents an increase of approximately 8 percent between existing and new resources, will be divided between two tiers. The Main Tier will be large-scale generators that sell power to the wholesale grid and will supply approximately 93 percent of the increase. The Customer Sited Tier will consist of small scale generators and will supply the remaining 7 percent (NYSERDA, 2010). Biogas projects are eligible resources for both the Main Tier and the Customer Sited Tier. The New York State Energy Research and Development Authority (NYSERDA) will manage the RPS tier program and allocate funds gathered through a surcharge on state investor-owned utilities (DSIRE, 2010b).

Anaerobic digester financial assistance of up to $1 million (mixture of grants and production incentives) is available for projects through the Customer Sited Tier program. Although the New York State RPS program has multiple layers and is somewhat complicated, the level of financial support available to anaerobic digester projects is a large contributing factor to New York being among one of the leading states in the number of installed on-farm anaerobic digestion projects.

Renewable Energy Certificates (RECs)

Renewable Energy Certificates (RECs) provide key information about renewable energy delivered to the electric grid. Most states allow utilities to use RECs in order to demonstrate compliance with an RPS. RECs can also be used to track voluntary efforts, at the utility or individual level, to increase renewable energy generation. RECs contain information about the environmental and non-power attributes of renewable electricity generation, including type of renewable resource, date when energy generation began, date when the renewable generation was built, renewable generator's location, RECs eligibility for certification, and greenhouse gas emissions associated with generation (U.S. EPA, 2008). RECs are an important tracking mechanism for the compliance market and can also monetize the value of renewable energy produced by allowing renewable energy generators to sell REC attributes into the compliance or voluntary market. There is some price volatility associated the sale of RECs which may present risk for the holder of the certificate.

Compliance and Voluntary Markets for Renewable Electricity

Renewable Energy Certificates (RECs) sold into a voluntary or compliance renewable electricity market could create a potential revenue stream for biogas projects. Prior to the passage of state level Renewable Portfolio Standards (RPS), renewable energy developers could market renewable electricity credits in a voluntary market either through an electric utility's green pricing program or to individual private interests to offset conventional electricity use at a facility.

The voluntary market has experienced steady growth over the last several years, which can partly be attributed to the increase in electric utility green pricing programs. The sale of green power, in kWh, increased by more than 50 percent in 2007 and annual growth rates have averaged 43 percent since 2004 (Bird et al., 2008).

A utility green pricing program offers an option to utility rate payers to purchase renewable energy above standard electricity rates (Bird, 2007). Voluntary purchases by customers require electric utilities to supply enough renewable energy to meet customer demand. Individuals can purchase RECs directly and do not need a utility green pricing program to make green power purchases. There are very few models for a utility green pricing program focused on electricity generated from biogas projects. Central Vermont Public Service operates one of the most successful green pricing programs for biogas electricity in the country, as profiled in the project highlight, *Central Vermont Public Service Cow Power™*.

In order to ensure the integrity of green power purchases and renewable energy credits used to achieve RPS compliance, several regional web-based tracking systems have emerged to verify RPS compliance and voluntary market transactions (Bird and Lokey, 2007). Regional tracking systems can help states follow the REC's path through a voluntary or compliance market and retire the credit once it has been used to avoid counting the credit again in the future (Bird and Lokey, 2007). In the Midwest, several systems are used to track renewable energy production. Nationally, nine tracking systems exist or are in development. Table 4 summarizes the compliance and voluntary market for green power purchases in Midwestern states and which mechanism is used to track the interaction of credits between markets.

Table 4. Compliance and Voluntary Market for Renewable Energy in Midwestern States

State	Compliance Market	Voluntary Market / Number of Utilities Offering Green Power Programs	Regional Tracking Mechanism
Illinois	Yes	Yes / 11	M-RETS/PJM-GATS
Indiana	No	Yes / 14	NARR/PJM-GATS
Iowa	Yes	Yes / 137	M-RETS
Kansas	Yes	No	NARR
Michigan	Yes	Yes / 6	MIRECS
Minnesota	Yes	Yes / 112	M-RETS
Missouri	Yes	Yes / 14	NARR
Nebraska	No	Yes / 4	NARR/WREGIS
North Dakota	Yes	Yes / 19	MRETS
Ohio	Yes	Yes / 12	NARR/PJM-GATS
South Dakota	Yes	Yes / 30	M-RETS/WREGIS
Wisconsin	Yes	Yes / 57	M-RETS

Source: Bird, Lori, Claire Kreycik and Barry Friedman. "Green Power Marketing in the United States: A Status Report (11th) Edition." Golden, CO. National Renewable Energy Laboratory. October, 2008.
U.S. Department of Energy, Energy Efficiency & Renewable Energy, Green Power Markets. National REC Tracking Systems Map. http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=3
For details on an individual utilities green pricing program visit http://apps3.eere.energy.gov/greenpower/markets/pricing.shtml?page=1

Regional Tracking Mechanism Abbreviations

Midwest Renewable Energy Tracking System (M-RETS)
Michigan Renewable Energy Certification Systems (MIRECS)
North American Renewables Registry (NARR)
Pennsylvania-Jersey-Maryland (PJM)-Generation Attributes Tracking System (GATS)
Western Reneawble Energy Generation Information System (WREGIS)

Net Metering

Net metering has been used as a policy incentive for locally-produced renewable electricity in 35 states. Under a net metering program, renewable electric generated by a utility customer enables the customer to run the electric meter backward to offset electrical use. Projects that produce excess generation and still remain under the capacity limit receive retail rates for the excess electricity fed to the grid (DOE, 2010). Table 5 summarizes the current metering policies for 10 Midwestern states. A limited number of biogas projects have been able to take advantage of net metering policies. Most net metering policies are targeted for small wind, solar, and hydroelectric. Biogas policy advocates have been supportive of increasing the capacity limit of current net metering policies to allow more biogas projects to capture the benefit. Even with an increased capacity limit, net metering policies will work for only limited number of biogas projects. In order to bring the resource to scale, additional policies addressing non-electricity uses of biogas need to be designed and implemented.

Production Incentives

The State of Minnesota has offered a production incentive as a policy mechanism to pull renewable energy projects producing electricity into the market. The program provides an additional payment to the renewable electricity supplier to supplement the utility buy-back rate for the electricity. Individual electric utilities have offered standard buy-back rates for renewable electricity,

Table 5. Summary of Midwestern Net Metering Policies

State	System Capacity Limit/Aggregate Capacity Limit	Applicable Utilities	REC ownership
Illinois	40 kW / 1% of utility's peak demand in previous year	Investor-owned utilities, alternative retail electric suppliers	Not addressed
Indiana *Photovoltaics, wind, small hydroelectric	10 kW / 0.1% of utility's most recent peak summer load (utilities may impose limit at their discretion)	Investor-owned utilities	Not addressed
Iowa	500 kW / no limit specified	Investor-owned utilities	Not addressed
Kansas	200 kW (non-residential), 25 kW (residential) / 1% of utility's peak demand during previous year	Investor-owned utilities	Utility ownership
Michigan	150 kW / 0.75% of utility's peak demand from previous year	Investor-owned utilities, electric cooperatives, alternative electric suppliers	Customer ownership
Minnesota	40 kW / no limit specified	All utilities	Not addressed
Missouri	100 kW / 5% of utility's single-hour peak load during previous year	All utilities	Not addressed
Nebraska	25 kW / 1% of utility's average monthly peak demand	All utilities	Customer ownership
North Dakota	100 kW / no limit specified	Investor-owned utilities	Customer and utility ownership
Ohio	Limit based on customer's load / no limit specified	Investor-owned utilities, competitive retail electric service providers	Not addressed
Wisconsin	20 kW (100 kW for wind for We Energies customers) / no limit specified	Investor-owned and municipal utilities	Not addressed

Source: Information included in this table was collected from the Database of State Incentives for Renewables and Efficiency (DSIRE). Visit www.dsireusa.org for more detail on any of the above net metering policies.

which is similar to a feed-in tariff or an advanced renewable tariff, discussed in the next section. Minnesota's production incentive originated in 1997 for wind energy and was expanded in 1999 to include hydroelectric in 2001 for biogas derived electricity and amended in 2007 to allow biogas production, not utilized for electricity, to qualify for the incentive (DSIRE, 2010b).

The production incentive ranged from 1.0¢ to 1.5¢ per kWh and payments could be made for up to 10 years. Payments were supported by the Renewable Development Fund, which is a fund financed by Xcel Energy ratepayers to support renewable energy development in Minnesota. The incentive payment for biogas production not used to produce electricity has yet to be calculated and it is possible no payments will be made since the program was closed to new applicants as of January 1, 2005 (DSIRE, 2010b). The Minnesota biogas production incentive may be a useful policy model for other states to provide an incentive for both electricity and renewable gas utilizations from biogas production.

Feed-in Tariffs (FITs)

Feed-in Tariffs (FITs) or Advanced Renewable Tariffs (ARTs) have entered the U.S. policy debate as an option to increase distributed generation of renewable energy resources and provide a payment structure to pull more capital intensive renewable resources into the renewable electricity market. A FIT policy originated in Germany in 1991 under the Electricity Feed-in Law, which guaranteed grid access for electricity generated from renewable energy and obligated utilities to pay premium prices for renewable electricity supplied to the grid. In 2000, the Electricity Feed-in Law was replaced with the Renewable Energy Sources Act which closely followed the original Feed-in Law (IEA, 2010). Renewable electricity generation doubled in Germany from 6.3 percent in 2000 to 11.7 percent in 2006 as a result of the Renewable Energy Sources Act (Büsgen, 2009). Government officials have also credited the policy with reducing carbon dioxide emissions by 57 million tons, increased energy manufacturing exports, and a rise in renewable energy sector employment (Büsgen, 2009). More information about the German biogas experience is contained in the project highlight, *German Biogas Industry.*

The German policy has also faced criticism due to the economic burden placed on consumers. A 2009 report by the Ruhr-Universität Bochum, Department of Economics,

Germany's principle support of renewable energy through FITs resulted in high costs without a net benefit on emission reductions, employment, energy security or technological innovation (Frondel et al. 2009). Other studies have determined that the transaction costs of the Germany policy are outweighed by the reductions in coal and gas imports for electricity generation in Germany. Decreased energy imports resulted in a savings of approximately €0.9 billion in 2007 (Büsgen, 2009). Examining Germany's experience with a feed-in tariff policy will be beneficial to U.S. states working to design and implement a similar policy. States will need to design a policy that can be workable within existing regulatory frameworks.

analyzed the increased cost of the feed-in tariff policy to industrial and private consumers. Utilities are legally obligated to comply with the policy, but utility customers bear the cost through increased electricity prices. The report estimated the increased cost to utility customers amounted to an additional 2.2 cents per kWh, roughly 7.5 percent of the average household electricity price of 20 cents per kWh. The report concluded that

The state of Wisconsin has experience in designing and implementing FITs/ARTs. Alliant Energy, an investor owned utility (IOU) offered a voluntary feed-in tariff to customers for renewable energy generation from photovoltaics, landfill gas, wind, biomass, and anaerobic digestion. Alternate buy-back rates were offered for different renewable energy projects and Alliant put in place a resource cap for each type of technology. The resource caps for each type of technology has been fully subscribed and the program is no longer available to new participants (DSIRE, 2010a). Alliant Energy's efforts to offer a voluntary FIT/ART is one of the contributing factors to Wisconsin leading the nation in the number of installed on-farm anaerobic digesters. Wisconsin's five largest investor-owned utilities, one generation cooperative, and one municipal utility are currently offering voluntary ARTs (Norcross, 2009). In early 2009, the Wisconsin Public Service Commission (PSC) began an investigation into the implementation of an Advanced Renewable Tariff (ART). The PSC began the investigation in response to a policy recommendation from Governor Jim Doyle's Task Force on Global Warming. The PSC asked Wisconsin utilities and other interested parties to comment on ART experience in Wisconsin and elsewhere, renewable electricity production costs, and ART policy and design issues.

As part of the Wisconsin PSC's ART analysis, the Commission used a spreadsheet to estimate future renewable energy production costs and analyzed a possible set of buy-back rates for different renewable energy technologies in varying size categories. Table 6 is derived from a more detailed summary table included in the PSC briefing memo

Project Highlight: German Biogas Industry

The history of biogas production in Germany first started with the utilization of marsh gas in the 19th century. Large steel drums with one open end were placed upside down in wetlands to collect gas for cooking fuel. During the latter part of World War II, Germany was in desperate need of vehicle fuel. They quickly developed anaerobic digesters to create and capture methane which was compressed at 3,000 pounds per square inch (psi) and used as transportation fuel. During the oil crisis in the 1970s, approximately 200 plants were built and operated. A decade later, former West and East Germany both took a large interest in biogas plants. East Germany focused on large centralized plants, while West Germany focused on farm-scale plants. Today there are approximatly 4,000 biogas plants operating in Germany, ranging in a variety of sizes and biogas utilization applications.

The rapid growth of the German biogas industry, from 200 plants in the 1970's to approximately 4,000 in 2009, is the result of accelerated activity on the part of farmers, utilities, and other industries, supported by a regulatory environment that strongly encourages the development of renewable energy. An additional 600-800 biogas plants are projected to be built in Germany in 2010, Some of this accelerated growth is due to renewable energy policies enacted by the German Federal Government. The German Cabinet adopted a comprehensive package to promote biogas utilization in December 2007. Changes were made and enforced in April 2008 to the Gas Grid Access Ordinance, the Gas Grid Fee Ordinance, and the Incentive Regulation Ordinance in order to make it easier to feed biogas into the natural gas grid. These changes complement the German Renewable Energy Act (EEG) that gives priority connection to the generation of electricity from biogas, a priority of purchase and transmission and a consistent fee for the electricity paid by the grid operators.

Germany is leading the way among developed countries in the construction and deployment of biogas plants. The German Biogas Association estimates that 1,000 new jobs will be created in 2010 and the Renewable Energy Act and the Renewable Gas Injection Act could potentially create 10,000 new jobs by 2020. Germany already has pure biogas filling station under construction, while a dozen biogas plants are being connected to the natural gas grid. By 2030, the goal is to make full use of biogas's potential of 10 billion cubic meters. Industry and policy committments in Germany have recognized that biogas can provide a meaningful contribtion toward energy independence, .

Policy Highlight: Ohio EPA Streamlined Solid Waste and Energy Recovery Permitting

As use of anaerobic digesters gain popularity, Ohio regulators are trying to reduce the paperwork requirements for permitting new projects. The Ohio Department of Agriculture (ODA) and Ohio EPA's Divisions of Surface Water (DSW) and Solid and Infectious Waste Management (DSIWM) have overlapping regulatory authority over projects that accept wastes not generated on-farm or at wastewater treatment facilities. The EPA is working to amend the solid waste rules for anaerobic digester projects that accept food scraps and other appropriate solid wastes. The revised rule aims to exempt combined feedstock digestion projects from the permitting requirements as a waste-to-energy facility when authorizations from DSW & ODA are already in place.

Ohio EPA is creating a new solid waste and energy recovery facility rule to exclude certain anaerobic digestion operations from a separate permit under the agency's solid waste program. Reducing unnecessary, overlapping regulation could ease the burden of permitting, encourage the establishment of anaerobic digester projects, and increase the amount of organic waste removed from landfills.

An existing exclusion t would allow hospitals, universities and manufacturing plants to establish a solid waste energy recovery facility using their own waste without requiring a solid waste permit.

Governor Strickland has directed Ohio state agencies to simplify rules and streamline inefficient and drawn-out regulatory processes. Eliminating unnecessary and burdensome regulatory standards will make Ohio a more competitive place to do business and a leader in anaerobic digestion projects.

for the ART docket describing possible buy-back rates for solar PV, wind, biogas, solid biomass, landfill gas, hydro, and other renewables indifferent size categories. Table 6 is only for biogas projects. The buy-back rates for biogas could provide an incentive to bring additional renewable electricity projects to market in Wisconsin. Possible rates included in the table would be for a 10-year power purchase contract. For biogas projects, the Commission indicated that a rate of return on investment at possible buy-back rates in Table 6 would largely depend on the capacity factor for a project; a low capacity factor could result in a recovery of costs, but not a profit and a high capacity factor could make a profit slightly higher than a typical utility rate of return (Norcross, 2009). The full analysis and documentation of the PSC's ART docket is available at www.psc.wi.gov.

Another policy that's similar to a feed-in tariff is a standard offer contract. The state of Vermont offers the best example of a standard offer contract program. In May 2009, Vermont enacted the Vermont Energy Act. Part of this act established the Sustainable Prices Energy Enterprise Development (SPEED) program, which requires Vermont utilities to purchase electricity from eligible renewable energy projects through a long-term contact with fixed standard offer rates (DSIRE, 2010e). After passage, the Vermont Public Service Board (PSB) moved to implement the policy quickly and issued final rules on January 15, 2010. The policy put in place an overall program cap of 50MW and a technology specific sub-cap of 12.5 MW. Contract applications for solar and biomass reached the technology cap on the first day the program was offered and the overall program cap of 50 MW was met within days (DSIRE, 2010e). The rapid fulfillment of the SPEED program in Vermont illustrates the incredible amount of interest among utility customers and project developers to supply renewable electricity to the grid.

Designing a feed-in tariff, advanced renewable tariff, or standard-offer policy for individual U.S. states is complicated by existing federal law. A January 2010 report from the National Renewable Energy Laboratory (NREL) should give pause to proponents working to advance state level FIT policies and examine additional measures that will be needed in order for state level policies to comply with federal law. The report entitled, "Renewable Energy Prices in State-level Feed-in Tariffs: Federal Law Constraints and Possible Solutions," examines two pieces of federal law governing electric utility regulation in the U.S.; the Public Utility Regulatory Act of 1978 (PURPA) and the Federal Power Act of 1935 (FPA). Both federal laws could complicate state efforts to design and implement a feed-in tariff policy. PURPA required utilities to purchase renewable electricity from project developers at or below the utilities avoided cost (the cost the utility would have paid for generation from another power source). FPA puts in place a process where every contract for the purchase of wholesale power must receive approval from the Federal Energy Regulatory Commission (FERC), unless the sale is subject to PURPA. A contract must be based on either cost-based or market-based rates; neither contract type allows for approval of a feed-in tariff where the rate is set by a state and the purchase price is higher than a rate for cost-recovery plus a reasonable return on equity (Hempling et al. 2010). These federal constraints could hamper state level efforts to adopt a feed-in tariff. However, state programs, such as the Vermont SPEED program, that offer to buy energy at a state-approved price rather

interest in examining feed-in tariff policy. Correctly designed, a FIT policy could have a large impact on bringing biogas projects to market, but given federal law constraints, additional policy mechanisms that could be implemented in the near-term should be closely examined. Feed-in tariff or advanced renewable tariff legislation has been introduced in Wisconsin, Minnesota, Michigan, Indiana, and Illinois. Given the interest by so many Midwestern states in FITs/ARTs, the policy will continue to receive careful consideration by state legislatures and renewable energy proponents.

than require utilities to enter into a contract at a set price could avoid conflicts with federal law (Hempling et al. 2010).

Existing federal constraints may complicate the implementation of a state-level feed-in tariff approach, but the NREL report does offer options for states to consider in order to comply with existing law. States that rely on PURPA can create a two-part payment structure; the first part of the payment is the utility's avoided cost and the second part of the payment is made through a supplemental mechanism (cash grant, REC, tax credit and/or production incentive payment) (Hempling et al. 2010). States that are subject to FPA can either seek a change in FERC precedence to allow utilities to contract with renewable energy suppliers at a rate above avoided cost or apply to FERC for approval of cost-based rate contracts or a blanket approval for market-based rate contracts (Hempling et al. 2010). Individual states and renewable energy advocates have demonstrated a strong

Regulatory agencies and actions

State regulatory agencies and actions play an important role in facilitating biogas project development. Permitting requirements can hinder development if the regulations are not clear or uniformly applied. The application of air quality regulations - specifically nitrogen oxide emissions - is resulting in the loss of permits for currently operating biogas-to-electricity projects in California. Details on this regulatory confusion are explained in the **Biogas Policies for Consideration** section of this report. State agencies collaborate with federal regulatory agencies to implement federal rules and regulations in addition to managing state regulatory requirements.

Project permitting

State agencies are responsible for issuing a variety of permits required for waste-to-energy projects. Waste-to-energy projects usually fall under air, water, energy, and solid waste regulations. The project permitting process can be difficult to navigate for project developers. Regulatory requirements become even more complicated when multiple feedstocks are used to produce biogas at a single project site. Each state has regulations regarding allowable amounts of feedstock brought into a waste-to-energy project site. Because waste-to-energy projects interface with several different permitting and regulating agencies, overlap and inconsistencies can exist between multiple state agencies. The state of Ohio has recently made revisions to permitting requirements to eliminate overlap and streamline permitting for waste-to-energy facilities as profiled in the policy highlight, *Ohio EPA Streamlined Solid Waste and Energy Recovery Permitting.*

Interconnection standards

Individual U.S. States determine the rules for connecting distributed renewable energy generation projects to the electric grid. These rules cover both technical and legal requirements and, if designed properly, can eliminate confusion and complexity for project developers and electric utilities. Every state in the Midwest, with the exception of North Dakota, has developed standard interconnection rules for distributed generation projects through a public utility regulatory body. The 2005 Energy Policy Act required state regulatory agencies to consider standard interconnection based on IEEE 1547[2] standard and available best practices (Vernado and Sheehan, 2009). The requirement to develop interconnection standards is needed to increase the amount of distributed generation resources in the electricity mix.

Table 6. Possible Biogas Buy-back Rates from Wisconsin PSC ART Docket (cents/kWh)

	Category 1 (≤ 20kW)	Category 2 (20-200 kW)	Category 3 (200 kW-1MW)	Category 4 (1-5 MW)
Biogas	Net metering[1]	10.7	10.5	9.3 (1-2 MW) 8.4 (2-5 MW)

Source: Briefing Memorandum Statement of the Proceeding - Docket 5-EI-148, May 20, 2009, Wisconsin PSC.

1- Wisconsin's net metering practices was adopted in 1982 and requires all regulated electric utilities to provide net metering for customer owned generating systems at or below 20kW of installed capacity.

2- IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems was approved by the IEEE Standards Board in June 2003. It was approved as an American National Standard in October 2003. The published standard is available from the IEEE Std 1547-2003 Web page.

Interconnection standards can be complicated and may vary from state to state. Standards, requirements, and costs can also vary by utility. The costs of upgrading electrical lines for biogas-to-electricity projects can be significant and can be the "make or break" factor determining a project's financial viability. Upgrading costs depend on several factors such as the project location along the distribution line and the type or age of electrical lines. This patchwork of rules can cause frustration for project developers working to site similar projects in multiple states. A complete review of interconnection rules and best practices falls outside the scope of this report. The Interstate Renewable Energy Council has detailed information and several reports dealing with interconnection issues available at their website, www.irecusa.org. The project highlight, ***Wisconsin Distributed Generation Interconnection Guidelines,*** profiles the interconnection rule development process in Wisconsin.

Policy Highlight: Wisconsin Distributed Generation Interconnection Guidelines

The Wisconsin Distributed Resources Collaborative (WIDRC) began as an informal group in 1999 with participants that included Wisconsin's investor-owned utilities, municipal utilities, electric cooperatives, equipment manufacturers, state agencies and renewable energy organizations. The group initially sought to update and simplify interconnection practices to take into consideration the progress in technology since utilities first became involved with customer-owned, distributed generation. Distributed generation (DG) is electric generation located at or close to the point of use and is an alternative to central station generation. In 2002, steps were taken to formalize WIDRC as a voluntary collaborative committed to facilitating and promoting the successful deployment of economic, efficient, and environmentally responsible distributed resources in Wisconsin. During the same time period and in response to enabling legislation, WIDRC was appointed as an advisory committee by the Public Service Commission of Wisconsin (PCSW) to establish uniform interconnection rules across the state and promote development of distributed generation. The rules developed addressed engineering, electric reliability, safety concerns and the methods of determining charges for interconnection.

Biogas is created in anaerobic digesters that break down organic waste. Biogas is utilized in micro-turbines and internal combustion engine generators to create electricity, which can be used on-site or sold to the local electric utility. The State of Wisconsin has encouraged distributed generation for biogas energy resources because it produces high-quality, reliable power in a way that reduces methane emissions from waste and reduces the need for fossil fuel generation and its accompanying carbon dioxide emissions. Distributed generation, located near loads, also utilizes more of the electricity produced, since 5-7 percent of total generation is typically lost in power lines delivering energy to consumers.

The WIDRC advisory group created the Wisconsin DG Interconnection Guidelines (PSC-119),which can be found on www.wisconsindr.org. The basic components of the Guidelines and the resultant PSC-119 rule - can be broken down into two types – 1) business & legal and 2) technical:

Business and Legal Related Rules

- application process (application, reviews, studies, interconnection schedules, agreements)
- standard application forms
- standard agreement forms
- development and layout of the Guidelines (the basis of the PSC 119)
- ISO, NERC, FERC jurisdictional issues
- fee schedules
- designation of one point of contact at each electric provider

Technical Related Rules

- DG size class determination
- distribution system impacts and upgrades
- national and state standards conformity
- equipment pre-certification requirements (UL 1742, IEEE 1547, etc.)
- safety and reliability issues
- protective function requirements
- testing requirements

Some features of the requirements are:

- DG must automatically disconnect upon loss of utility power ("anti-islanding" protection);
- Visible and accessible by utility staff "interconnection disconnect switch;"
- One designated contact at each utility;
- Small pre-approved DG equipment is type tested to UL 1741[3] ; and
- Standard application and agreement forms must be completed.

The state of Wisconsin is leading the industry in the number of on-farm anaerobic digester projects and that leadership can be attributed in part to supportive state-level public policies..

3- http://ulstandardsinfonet.ul.com/scopes/1741.html These requirements cover inverters, converters, charge controllers, and interconnection system equipment (ISE) intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Utility-interactive inverters, converters, and ISE are intended to be operated in parallel with an electric power system (EPS) to supply power to common loads.

Biogas Policies for Consideration

A common theme expressed by almost all of the stakeholders is a desire for future policy to level the playing field between direct incentives and grants for biogas production that would produce electricity, renewable natural gas, or other utilization options. Private financing from traditional lenders is an obstacle to bringing projects online, and future biogas incentives must take into account these commercial lending obstacles. The right policy environment should provide the right framework for project developers to determine the highest and best use for the biogas produced and not limit the technology applications for producing biogas or biogas utilization options.

As the biogas industry has developed over the last several years, the number of experts working in the field has also grown. In order to gain a richer understanding of existing successful policies and those that could be implemented to further help develop the industry, informal discussions took place with a diverse group of industry stakeholders from January to May, 2010. A full listing of these experts can be found in the acknowledgements section of this report. These experts have experience developing and implementing individual projects, advancing policy at the federal or state level, analyzing the current industry, and developing technical and policy solutions to grow the industry.

In order to effectively summarize all of the input collected from discussions with 40 industry stakeholders, five categories have been developed specifically for the policy discussion:

- **Existing Policies that are Best in Class:** policies that were referenced by a majority of stakeholders as successful examples were placed in this category. Although successful examples exist, it is important to note additional changes could make these programs even more effective.

- **Existing Policies that Just Need a Tweak:** existing policies where a change was recommended were placed this category. Changes recommended were in the spirit of improving the effectiveness of a policy for biogas projects.

- **Proposed Policies that Just Need a Push:** currently proposed policies at the state or federal level that have not been passed were placed in this category. Some policies in this category have seen several attempts at passage at the federal or state level or have received a previous level of policy debate.

- **Promising New Policies that Need a Champion:** all new policy ideas not currently proposed as a formal piece of legislation or have not had multiple attempts towards passage were placed this category.

- **Other Ideas:** stakeholder recommendations that do not require or were not ready for legislative or regulatory action were placed in this category.

This section also contains examples of model state-level policies that could be replicated in other states to increase biogas development. Also included is discussion on emerging industry trends outside of the policy arena that hold potential to drive to the industry.

The policies, regulatory actions, and ideas presented in this section are solely a starting point for additional discussion and should be considered high- level recommendations. All of the recommendations presented in this section are not final and need additional discussion on specific mechanisms or language required to actually implement the high-level recommendations.

Existing Policies that are Best in Class

Clean Renewable Energy Bonds (CREBs) have been an important tool in financing biogas projects for ownership models beyond individual farms. Electric cooperatives and municipalities have been able to use CREBs financing to secure a tax credit for eligible, electric-generating projects.

Environmental Quality Incentives Program (EQIP) is a cost-share program authorized by the Farm Bill. EQIP is a voluntary program for agricultural producers to implement structural and management conservation practices. Agricultural producers are eligible to receive cost-share assistance for constructing manure management and storage equipment. Manure storage is a necessary component for an on-farm biogas system. Based on state conservation priorities, individual state NRCS offices can offer cost-share assistance to agricultural producers for the implementation of an anaerobic digestion system in addition to EQIP cost-share assistance for manure storage. EQIP has provided an additional way to defray capital costs associated with the construction of on-farm anaerobic digestion systems.

Rural Energy for America Program (REAP), a program originally created as part of the 2002 Farm Bill and formerly known as the 9006 program, was often cited during conversations with stakeholders as one of the most successful policies for building biogas projects. REAP provides grants and loans to agricultural producers and rural small businesses to implement renewable energy and energy efficiency programs. On-farm anaerobic digestion projects have captured 15 percent of total project awards from 2003 to 2009 (ELPC, 2010). Although most stakeholders point to REAP as a hugely successful grant program that has defrayed some of the capital costs for projects, the timing and availability of funds has been problematic. REAP applications are now accepted on a continuous basis, but when and if a project receives funding is still dependant on the annual appropriations process, which is becoming more difficult as the federal deficit continues to grow. Additional changes could be made to the REAP program to clarify and standardize the applicability of the grant program, such as structuring the grants to cover projects costs over time and not just the upfront capital costs (Innovation Center for U.S. Dairy, 2010).

State-level grant programs, such as the Wisconsin Focus on Energy anaerobic digestion grants, have provided a source of project funds to be matched with federal funds in order to bring more projects online. State-level grants have helped project developers defray capital costs. However, as state budgets tighten across the region and large deficits loom, there may be less opportunity for state-level grant programs. State-level policies have been a key factor in helping to build the current biogas industry, and policymakers should examine additional ways for state-based policies to help the industry continue to grow.

State-level Renewable Portfolio Standards (RPS) are statutory requirements for electric utilities to include a specific percentage of renewable energy in their portfolios. Currently 29 states have an RPS mandate and six states have goals. Several stakeholders discussed the importance of state-level standards to create a market for renewable energy. An RPS appeared to be particularly useful in driving biogas project development in states that do not have a strong wind resource. States with a strong wind resource were focused on scaling up wind energy generation, but in states where a strong wind resource was lacking, electric utilities were looking to other renewable energy resources, like biogas, to help meet the state mandate or objective. Although an RPS is not a direct biogas policy incentive, it encourages diversification of the electric mix and offers many indirect benefits for the biogas industry.

Voluntary feed-in tariffs offered by select investor owned utilities (IOUs) have contributed significantly to biogas project development. IOUs that have offered a voluntary tariff have quickly met their set resource cap and have had struggled to meet addition customer demand for proposed biogas projects. Given the complexity of federal constraints for a state-mandated feed-in tariff program, industry stakeholders would like to see more electric utilities offer voluntary tariff programs to spur development.

Existing Policies that Just Need a Tweak

Business and Industry Guaranteed Loans (B&I) is a program under USDA Rural Development that provides guaranteed loans for rural cooperative organizations that process value-added agricultural commodities. Commercially available energy projects that produce biomass fuel or biogas are eligible for this program. The largest obstacle for biogas projects seeking a guaranteed loan from this program is the requirement to have a traditional lender in hand. New businesses proposing projects do not have access to balance sheets from previous years to secure a traditional lender. Additional flexibility mechanisms should be examined to allow newly formed businesses the opportunity to receive guaranteed loans through this program.

Business Energy Investment Tax Credit (ITC) has traditionally provided tax credits from the federal level for solar power, fuel cells, small wind farms, geothermal energy, microturbines, and combined heat and power facilities. Industry stakeholders involved with projects that produce renewable gas instead of electricity would like to see the ITC modified to allow renewable gas projects to also qualify for the tax credit.

Net metering Provisions are not a perfect policy solution to incentivize biogas projects, but come closest in providing a fair price for electricity production from biogas if the rate is based on the retail price for electricity. If utilities are supportive, the net metering limit for distributed generation projects could be raised to bring more biogas projects online. A tiered net metering provision could also be

adopted that would have varying capacity limits for different renewable energy technologies. Net metering provisions vary state by state and a summary table of Midwestern net metering policies is included in the state policy section of this report.

Renewable Electricity Production Tax Credit (PTC) is a federal tax credit program that has been in operation since 1992 with intermittent periods of availability depending on Congressional program extensions. Three suggested changes to the PTC emerged from stakeholder discussions: extend the time period the PTC is available to give investors financial assurance; allow non-electrical production to qualify for a tax credit either through the PTC or a new non-electrical production focused credit; and offset the tax liability, or accelerate depreciation to make the credit more workable for farmer-owned biogas projects. A longer period of availability for the PTC would provide projects with adequate time to secure necessary project permitting before construction commences.

The standard interconnection agreements that currently exist in most Midwestern states may not be sufficient to bring additional biogas-to-electricity projects online. Utility interconnection was referenced as a major barrier to biogas development during many stakeholder discussions. However, industry stakeholders did recognize efforts already undertaken by Midwestern electric utilities and public regulatory commissions to develop standard interconnection agreements. Additional work is needed in this area, such as developing model equipment standards that move beyond standard procedures. The Interstate Renewable Energy Council is conducting a considerable amount of work in this area and several resources are available on their website, www.irecusa.org.

The Wisconsin Standard Interconnection Guidelines previously highlighted in the state policy section of this report are worth mentioning as a model policy that could be replicated in other states. The guidelines (developed through the Wisconsin Public Service Commission) addressed engineering, electric reliability, safety concerns, and methods to determine charges for interconnection. Stakeholders highlighted the positive impact of these standards to bring new biogas projects online in Wisconsin. Although standardinterconnection guidelines can be developed, project developers should expect interconnection to vary slightly from utility to utility, but standard guidelines can be used as a helpful starting point to connect a project to the electric grid.

State-level Renewable Portfolio Standards (RPS) could be modified in several ways to provide additional incentives for biogas projects. Stakeholders suggested adding a resource carve out for existing or new RPS policies, allowing renewable natural gas projects to count towards the RPS (see additional explanation under enhanced renewable energy standard in promising new policies section), setting higher percentage targets, adding enforcement mechanisms for failure to meet the standard, and applying the standard to electric cooperatives in states where cooperatives are exempt from meeting the standard.

U.S. Department of Treasury, Section 1603, was included as part of the 2009 American Recovery and Reinvestment Act (ARRA) and provides a grant for up to 30 percent of construction and installation costs for a depreciable or amortizable renewable energy facility in lieu of tax credits. The current program excludes open-loop biomass facilities that have a nameplate capacity rating of 150 kilowatts or less. Project developers expressed an interest in adding non-electrical uses for biogas to qualify as eligible projects. Project developers referenced this program as a helpful policy to build projects and would like to see the program extended to at least 2012. Senator Diane Feinstein of California and Senator Jeff Merkley of Oregon introduced legislation (S.2899) at the end of 2009 to extend this program through 2012.

Proposed Policies that Just Need a Push

The Biogas Production Incentive Act (S. 306/H.R. 1158), authored by Senator Ben Nelson of Nebraska and Representative Brian Higgins of New York, was introduced in 2009.

The proposed legislation would provide an incentive for the production, sale, or use of biogas derived by processing a qualified feedstock in an anaerobic digester. Recently proposed changes to the original legislation would include criteria for high-and low-BTU gas. An emphasis on high-BTU gas would make this policy less workable for farm-based systems. Overall, the policy should focus on BTU output and not gas quality in order to be applicable to the greatest number of potential projects.

A federal cap on carbon emissions would be a game changer for the biogas industry. Due to the ability of biogas projects to capture methane, a greenhouse gas with 25 times the heat trapping power of CO_2, a federal cap on carbon emissions would create an enormous opportunity to generate and sell carbon credits to a regulated entity to help meet the

cap. A federal climate policy capping electric-sector or economy-wide carbon emissions that includes a robust carbon credit trading program could provide an additional revenue stream, depending on the offset price, to drive significant biogas project development. The voluntary carbon market has been able to provide a small economic sweetener for biogas projects, but on its own has not pulled biogas projects into the market. The House-passed American Clean Energy and Security Act will need to be reconciled with a yet-to-be-passed Senate version. The timing of a possible Senate bill addressing carbon emissions is unclear.

Federal Renewable Electricity Standard (RES) would create a uniform, minimum standard across the United States and would provide reasonable assurance to potential projects of a market for renewable electricity. A federal RES should not preempt established state programs that require a higher percentage of renewable electricity than a federal program. A federal RES would also create a national REC market and the national market should treat RECs as a fungible resource, allowing credits to pass across state lines. This would open the door for biogas-to-electricity projects in one region of the country to sell RECs to an electric utility in another part of the country to help the utility meet the federal requirement.

Investment tax credit for biomethane projects is a legislative proposal by Representative Ron Kind (D-WI) that would provide a 30 percent credit for biogas projects producing gas at least 52 percent methane and utilizing the gas as a fuel. This proposal mirrors the current investment tax credit available for open-loop biomass projects producing electricity. Making a credit available to biogas projects producing electricity or renewable gas will allows project developers to determine the highest and best use

Project Highlight: California Creativity-Cow Power- Hilarides Dairy Farm

Third generation dairy farmer, Rob Hilarides, has the attention of the public, not just because of his dairy farming practices but because his cows are powering the semi-trucks that haul the milk they produce. Hilarides Dairy operation is using the manure from the 6,000 head of dairy and heifer cows to help generate electricity for the operation, as well as fuel for four tractor trailers and seven pick-up trucks.

The Hilarides were able to set up a comprehensive manure management system when after consolidating three separate dairies to one large central dairy operation. The operation uses a flush and gravity flow system to move manure into covered lagoons. Biogas is pumped to six Caterpillar G342 generators, which generate 750 kilowatts of electricity--more than the dairy is able to use. The rest of the biogas is purified and pressurized to be used in the semi-trucks' natural gas Cummins-Westport engines and seven pick-up trucks for dairy personnel. The digested manure is applied to the Hilarides' cropland, which is used to grow corn, wheat, and alfalfa to feed the cows.

The California Air Resource Board Alternative Fuel Incentive Program for the "cow power- truck project" provided funding to cover a portion of the system costs. Hilardies Dairy also received funding from the California Dairy Power Production Program.

Hilarides Dairy has found that using cow manure to produce biogas can cut greenhouse gas emissions in two ways. Biogas creates less pollution compared to conventional fuel and reduces methane released into the atmosphere because it is captured and used. At Hilarides Dairy, the manure creates enough biogas to reduce their fuel consumption by nearly 770 gallons per day. California dairy cows alone could displace more than 150 million gallons of gasoline a year. Some analysis suggests that the nation's dairy cows could generate enough fuel to power one million vehicles, which would be equivalent to removing 16 million vehicles from the road.

for the gas. The Rep. Kind ITC proposal is a step toward providing a broad portfolio of incentives for biogas project development.

Low Carbon Fuel Standard (LCFS) is a policy that seeks to reduce the average carbon intensity of transportation fuel in the aggregate over a specified period of time. California was the first state to enact an LCFS. Other U.S. states and regions are exploring implementing a similar policy. As part of California's implementation of an LCFS, the state Air and Resources Board completed life-cycle analysis of several fuel pathways, including compressed and liquefied natural gas derived from biogas produced at livestock operations. The fuel pathways for livestock biogas scored among the lowest of all fuel pathways for total carbon intensity on a life-cycle basis. An LCFS or a similar policy could pull projects producing biogas suitable for use as a transportation fuel into the market. The project highlight, *California Creativity-Cow Power-Hilarides Dairy Farm*, profiles a project producing biogas for transportation fuel use.

The Renewable Fuel Standard (RFS) was first established in the Energy Policy Act of 2005 and set a volumetric mandate of 7.5 billion gallons of renewable liquid fuel to be blended with gasoline by 2012. The 2007 Energy Security and Independence Act (EISA) expanded the volumetric requirement to 36 billion gallons by 2022. EISA also expanded fuel resources used to meet the mandate beyond liquid fuels, such as ethanol and biodiesel, to include electricity and biogas derived from renewable biomass. The EPA has finalized rulemaking for RFS2 and assigned an equivalence value of 77,000 BTUs of biogas to equal one gallon of renewable fuel. According to the EPA, biogas includes propane landfill gas, manure digester gas, and sewage waste treatment gas. Although EPA has put rules in place to allow for biogas used as a vehicle fuel to count towards the total RFS2 volumetric requirement, biogas to vehicle producers must petition EPA to be assigned a Renewable Information Number (RIN) in order to receive the credit. RINs are used to track RFS2 compliance among fuel importers and refiners. An additional RFS modification could assign a cellulosic, advanced, or renewable fuel RIN for corn ethanol plants sited next to biogas projects supplying renewable natural gas to offset conventional gas use at ethanol plants.

Promising New Policies that Need a Champion

Divert source separated organics from landfills through local regulations. Some stakeholders pointed to the possibility of capturing a greater percentage of methane from source separated organics by keeping them out of the landfill and putting the material through a biogas project. Others suggested this was an area that needed further research to determine how much more methane could be captured through anaerobic digestion rather than material disposal in a landfill and if the costs of additional infrastructure could be recouped. Stakeholders were in agreement that existing landfills should be capturing methane and that an organic diversion policy has future potential.

Enhanced Renewable Portfolio Standard was a proposed policy in Wisconsin that did not pass during the 2010 legislative session. The Enhanced RPS policy in Wisconsin would allow electric utilities to count renewable natural gas injected into the pipeline, thermal energy from combined heat and power, or cogeneration projects towards the state RPS. In order to implement this policy, a conversion factor for thermal energy and renewable natural gas would need to be established through a regulatory process renewable energy certificates (RECs) used to track the resource. Supporters of the policy argued that it would add flexibility for electric utilities and would build a market incentive for upgraded biogas to renewable natural projects, which currently does not exist. States that currently do not have an RPS could consider including these renewable energy resources in a policy definition of eligible sources and states that already have an RPS policy could examine the possibility of revising the existing definition to includes these sources. The enhanced RPS was a part of a larger legislative package that was unable to receive majority support before the end of the legislative session in 2010.

Feed-in Tariffs (FITs) or Advanced Renewable Tariffs (ARTs) was a policy referenced in a majority of stakeholder discussions either as a potentially positive or problematic policy. The state policy section of this paper discusses the German experience resulting from the implementation of a feed-in tariff policy and potential federal law constraint considerations when designing a similar policy at the individual state level. Although this policy is a high prospect among several stakeholders, possible federal constraints are an issue needing careful consideration when moving ahead at the state level. Stakeholders referenced FITs as a promising policy for agricultural based projects and industrial and municipal projects.

Green pricing programs for natural gas could begin to provide some parity for biogas projects producing electricity or renewable natural gas. Natural gas utilities have conducted some initial examination of green pricing programs for natural gas, but policy changes at the legislative or regulatory level are required in order for utilities to offer a price for "green" gas that would be higher than the standard production cost. The project highlight, *Scenic View Dairy Renewable Natural Gas and Electricity Production*, profiles a project in Michigan that could benefit from renewable gas incentives. Renewable gas incentives could also bring similar types of projects into the market.

Project Highlight: Scenic View Dairy, Renewable Natural Gas, and Electricity Production

Scenic View Dairy, located in Fennville, MI is not only the first on-farm digester in the state to interconnect with the electrical grid, but also the first digester in the U.S. to generate both electricity and pipeline-grade natural gas. The project originally installed two 350 kW generator sets, but the addition of a syrup stillage substrate boosted biogas production requiring the need for additional utilization. The biogas upgrading system was installed in 2007. The 2,000 dairy cow operation and 1,450 young heifers produce more than 25 million gallons of manure each year. The Dairy has partnered with Phase 3 Renewables to help convert the waste into pipeline-grade natural gas, which will be used by Michigan Gas Utilities Corporation (now owned by Integrys), serving over 162,000 customers.

The dairy operation uses a complete-mix anaerobic digestion treatment facility with a scrape system that delivers the manure from the main barns to a manure holding pit. The manure is pumped into three large digester tanks, where it is exposed to intermittent agitation. The biogas collected from these tanks is piped out and used in two generators to produce power for the farm or is upgraded and fed into the public natural gas pipeline for local distribution and use. The two 400 kW Caterpillar generators create waste heat which is used to keep the digesters at ideal temperatures. Excess generated electricity is sold to Consumers Electric Company.

Scenic View Dairy's project came online in June 2006 and by February 2007, the natural gas injection system was operational. The whole system cost was approximately $3.1 million, including $1.2 million for the digesters, $650,000 for the biogas upgrading systems, and $1 million to connect to the grid. Scenic View Dairy was the first site to produce both electricity and pipeline natural gas, with an output of 800 kilowatt-hours of electricity and 75 cubic feet per minute of pipeline gas.

National or Individual State Nutrient Trading Programs, modeled after a program in Pennsylvania (discussed in model state level policies), could begin to monetize the value of water quality benefits from farm-based biogas projects. In a final statement on water quality trading policy, the Environmental Protection Agency stated, "market-based approaches such as water quality trading provide greater flexibility and have potential to achieve water quality and environmental benefits greater than would otherwise be achieved under more traditional regulatory approaches," (EPA , 2003). A possible vehicle for this policy could be the 2012 Farm Bill.

Restrictions on land application of biosolids would drive developers to examine alternative uses of biosolids and could divert biosolids towards biogas projects. A review of existing regulations is needed in order to determine appropriate revisions to existing regulations.

Rural Infrastructure Development Fund could be established at the national level to provide assistance to individual project developers and rural electric utilities to upgrade electric distribution infrastructure. Inadequate electrical lines to carry renewable electricity produced from an agricultural site are a limiting economic and technical factor for biogas projects. Current developers that decide to upgrade electric service to a project site shoulder the cost associated with upgrading distribution infrastructure. A funding pool in the form of grants, loans, or tax credits could be established to provide financial assistance to share the costs of updating electric distribution infrastructure in rural America.

Tradable tax credits could supplement the buyback rate offered by a electric or natural gas utility. The project owner could sell the credit to a utility or another entity to use the credits and, in turn, provide an extra investment for the project owner to finance a project.

Utility conservation program investments could be a source of project investment by natural gas and electric utilities. Conservation programs require electric and natural gas utilities to invest a portion of revenues into conservation projects. Legislation or a regulatory action would be required to change conservation program investment language to allow biogas used on-site to power an industrial scale facility to qualify for program dollars. The biogas produced would need to be used directly by the generating facility and not distributed into the electric or natural gas distribution grid. Utility conservation programs prohibit fuel switching projects to qualify for conservation investments and a legislative or regulatory fix might be required to clarify that closed-loop biogas projects would not constitute fuel switching.

Model State Level Policies

Iowa Program Implementation Guideline (PIG) is a regulatory level guideline from the Iowa Department of Natural Resources that helps streamline the permitting process for waste-to-energy project developers by organizing a meeting between a project developer and all relevant DNR departments responsible for permitting projects. The process minimizes surprises and ensures that project development proceeds smoothly. Project developers can also be connected to other relevant state agencies that have permitting requirements. This program does not require any state legislation or specific regulatory action to replicate in other states. Agencies in other Midwestern states could begin to implement a similar program immediately and make a big difference toward attracting future biogas projects. Regulatory transparency and cooperation is a critical component for waste-to-energy projects to succeed.

Pennsylvania nutrient trading program for point sources was finalized in 2006 and allows point sources of pollution to offset discharges by purchasing credits from other facilities or agricultural producers (Showalter, 2007). The program was created in response to severe water impairments in the Chesapeake Bay resulting from nutrient loading, such as nitrogen and phosphorus, from local watersheds. The trading program operates similarly to a cap and trade program for greenhouse gases. Any party can trade credits with other parties in order to meet the allowable nutrient load set for the watershed. Trading can take place between any combination of point sources, nonpoint sources, and third parties (Pennsylvania Department of Environmental Protection, 2010). This program recognizes water quality contributions resulting from land application of liquid manure that has been separated from the solids portion of manure. The liquid portion retains the nitrogen needed to fertilize soil and phosphorus is contained with the solid portion of the manure. Research is underway on new technology applications that can use chemical processes to pull phosphorus out of digested manure. Best management practices for appropriate nutrient application of digested or raw manure could also generate a credit in a nutrient trading program regime.

Other Ideas

Carbon credit certification assistance would provide the opportunity for smaller biogas projects to defray certification costs, which are essentially the same for large or small projects, and sell or trade carbon credits in a voluntary or mandatory market. A cost-share assistance program could be administered through USDA, carbon credit aggregators could provide package discounts to multiple smaller biogas projects in a geographic location, or livestock organizations or farmer cooperatives could provide assistance as a service to their members. Options to provide assistance for carbon credit certification to smaller projects is an area needing further discussion and examination, especially if a federal cap-and-trade program is put in place.

Closed-loop projects present an opportunity for future biogas projects because the biogas created at the project site can either be used on-site or by a nearby customer. Closed-loop projects would avoid the step of needing to market biogas produced into the electric or natural gas distribution infrastructure. Financing mechanisms or potential incentives for closed-loop projects should be examined more closely. Many existing incentives are tied to energy production or utilization of the gas. A possible area of financing for closed-loop projects could be electric or natural gas utility conservation programs. Stakeholders also pointed to models where biogas projects would be sited near ethanol plants in order for the biogas project to provide renewable natural gas as a replacement for conventional gas.

Federal and state government purchases of renewable energy could help to create demand for projects. Specifically for biogas projects, USDA could purchase renewable energy certificates (RECs) to offset conventional electricity use at office buildings in Washington D.C. and at USDA service centers around the country. These purchases would promote and help further develop renewable energy.

Increased coordination and interaction among agencies that award project grants and agencies responsible for issuing project permits is needed to facilitate additional biogas-to-energy projects. Stakeholders who work closely on project development also pointed out the need for better coordination between state and federal agencies. Depending the on the state, rules and regulations can vary between agencies. A needed next step would be to identify opportunities for increased agency cooperation at the state or federal level and develop recommendations for addressing coordination issues.

Integrate existing USDA programs to focus available funds on different components of a farm-owned biogas project. Currently, agricultural producers who are interested in implementing a biogas project must use a patchwork of grant or cost-share programs to reduce the project's capital investment. Most programs are available through USDA and an agricultural producer is the eligible applicant. USDA could provide guidance to potential applicants by dedicating available programs to different aspects of a project. For instance, the Environmental Quality Incentives Program (EQIP) could pay for manure storage and handling, the Rural Energy for America Program (REAP) could cover electrical generation equipment and the Biomass Crop Assistance Program (BCAP) could be used to incent the production of feedstocks for a project. USDA should examine all current programs that can be used to provide financial project assistance and issue guidance to potential applicants about which programs can be used to fund portions of a project.

Model solid waste regulations for waste-to-energy facilities could provide guidance to states considering changes to current solid waste regulations. Each individual state is responsible for the regulation of solid waste and currently each state has different rules and regulations for the amount of allowable solid waste to be brought into a waste to energy facility and used for co-digestion. A first step is to examine existing regulations and identify common threads among states. A review of existing regulations would also provide assistance to project developers trying to construct projects in multiple states. A second step would be to develop model regulations, providing an opportunity to bring all industry stakeholders together to achieve consensus on a workable set of regulations for waste-to-energy projects.

federal policies aimed at biogas or biomass projects

Premium price for consumer food products coming from farms producing biogas as a usable form of energy. Proposed efforts by individual retailers to include carbon footprint information on products would be a necessary first step to begin to provide information to consumers. Retailer labeling efforts could be coupled with a premium price offered for lower carbon products. The premium price for a product would need to flow through the entire product chain, shared by a retailer, distributor, processor, and producer.

Project coordinators for on-farm biogas projects, provided as a service by the electric or natural gas utility or technology provider, could supply valuable assistance to individual livestock producers who are interested in operating and managing an on-farm system but do not have access to resources to apply for grant funding, determine project permitting requirements, or leverage available production incentives.

Standard definition language for both state and should be developed and widely accepted by industry stakeholders. Slight differences in resource and technology definitions can cause inconsistency in the application of policies, creating additional obstacles for project implementation.

Industry stakeholders would prefer to see a standard definition that focuses on the energy value of biogas production and does not direct incentives toward a specific utilization of the gas, such as electricity production or renewable natural gas. Biomass definitions should be consistent between federal and state policies and programs.

Standard gas quality specifications and pipeline injection best practices for upgraded biogas, also known as biomethane could begin to provide assurance to project developers and natural gas utilities interested in purchasing renewable gas from biomethane projects. Currently, gas specifications only exist for geologically formed natural gas and specifications for renewable gas could begin to provide an additional market opportunity for biomethane projects. After gas quality specifications are set, best practices or industry standards for injecting biomethane into the pipeline need to be developed. Development of these standards and best practices could help renewable gas projects overcome pipeline injection barriers.

Third party management models for farm-based systems will need to be developed in order to bring projects to scale. It is unrealistic to expect that a majority of livestock producers will have a strong interest in being the sole manager for an energy production system on their farm. The dairy industry may explore the option of milk cooperatives contracting farm-based system management as a service to their members. Cooperatives could also help with securing financing for a project byproviding technical assistance to construct the system and assisting with carbon credit certification and trading. In addition to offering this as a service to their members, cooperatives would also gain a marketing advantage and be able to market their milk as having a lower carbon footprint. These options and programs will become especially important as Walmart moves to implement their Sustainability 360 initiative, described in the **Industry Trends; Positive and Negative** section. Exploring a third party management model with milk cooperatives keeps project benefits within the dairy industry. Similar models could be developed for other livestock sectors.

Industry Trends: Positive and Negative

American Biogas Council (ABC) is a newly formed industry trade group solely focused on advancing beneficial biogas policy at the federal level. ABC is also interested in forming regional networks across the U.S. to develop complementary state policy mechanisms. The ABC is the first nationally coordinated effort to give a voice to the biogas industry on Capitol Hill and in state legislatures. As the ABC continues to grow and improves organizational capabilities, the resource potential of biogas to help meet our future energy needs will be known more widely by elected leaders.

Confined Animal Feeding Operations (CAFOs) regulations could drive biogas project development as regulations tighten for CAFOs. Industry stakeholders do not think installation of an anaerobic digester should be mandated by a CAFO regulation, but instead should be added as a best practice to a technical manual. Best practice standards for anaerobic digestion at CAFOs could be addressed at the state level or at the national level through the Environmental Protection Agency.

New federal agency initiatives announced in the last year indicate that federal agencies are stepping up efforts to develop biogas resources. At the U.N. Climate Change Conference in December 2009, USDA announced an agreement with the Innovation Center of U.S. Dairy to accelerate and streamline anaerobic digester adoption by dairy operators to help achieve a goal set by the dairy industry to reduce greenhouse gas emissions by 25 percent by 2020. As part of the 25 percent goal, a project called Dairy Power seeks to facilitate the development of an additional 1,300 anaerobic digestion projects at dairy farms by 2020. The Memorandum of Understanding signed by USDA and the Innovation Center for U.S. Dairy outlined some possible actions for USDA, including simplified and integrated program application for U.S. dairy producers, improved financial feasibility studies for anaerobic digesters, improved timing of USDA programs, grid connectivity, and cap and flare technologies.

In early May, EPA and USDA announced an interagency agreement to promote renewable energy generation and cut greenhouse gas emissions in the livestock sector. This agreement will largely expand the work of the AgSTAR program and will provide up to $3.9 million over the next five years. The partnership will seek to expand technical assistance efforts, improve technical standards, increase outreach to livestock producers, and provide pre-feasibility study assistance.

Nitrogen oxide (NOx) emission regulations are tightening in California for biogas to electricity projects. When biogas is burned in internal combustion engines, NOx emissions are produced. NOx emissions are of special concern to California, especially in the San Joaquin Valley. The San Joaquin Valley has some of the dirtiest air in the nation and NOx levels for the valley are set by the federal government as part of the Clean Air Act (Huffstutter, 2010). Due to the low level of allowable NOx emissions, existing biogas to electricity projects need to make investments in expensive emission control technology and newly proposed biogas to electricity projects are being denied permits. Research is taking place on low NOx engines to comply with the California NOx emission standards. Operational and proposed biogas projects are exploring the feasibility of upgrading raw biogas for injection into the natural gas pipeline to avoid NOx emission requirements. Industry stakeholders are carefully watching what is occurring in California to prevent similar regulatory burdens in other states, which could have a negative impact on future biogas development across the country. Technology developers are also working toward alternative low-cost biogas utilizations that would not produce NOx emissions.

Walmart's Sustainability 360 Initiative was launched in 2005 under three operating goals: "to be supplied 100 percent by renewable energy; to create zero waste; and to sell products that sustain our resources and the environment" (Walmart, 2010a). Walmart has several strategies to achieve these three broad, ambitious goals. In July 2009, Walmart announced plans to create a worldwide sustainability product index as one strategy to help achieve the goal of selling sustainable products. The index will not be owned by Walmart, but will be a publically available searchable database. Walmart has proposed three steps to create the index: deploy a supplier assessment survey; create a product lifecycle assessment; and develop a tool for customers to gain access to product information (Walmart, 2010b). Walmart's efforts to conduct lifecycle assessments for all products sold in their stores will be a collaborative effort with universities and non-governmental organizations. Walmart's Sustainability 360 initiative will push environmental and energy improvements all the way through their supply chain, and livestock producers who are able to take advantage of biogas projects could have a competitive advantage selling their products to Walmart.

Biogas Research

Policy can help to drive development of biogas projects, but research is vital to ensure biogas projects increase efficiency and output over time. University-level research has played a role in the current biogas industry. General understanding about biogas technology and its effects would be limited without laboratory and practical research at public institutions. Several stakeholders pointed to the valuable contributions of the EPA AgSTAR program in providing key information and technical resources for the farm-based biogas industry. AgSTAR, working with state and regional partners, has developed reporting and evaluation protocols to determine project feasibility and long-term impacts. The technical resources and national coordination provided by the AgSTAR program have made valuable contributions to the biogas industry.

In the Midwest, Iowa State University's Agricultural Waste Management (AWM) lab has served as a valuable research site for biogas projects. The AWM lab has conducted lab, bench, and full-scale analysis of feedstocks for anaerobic digestion. Lab analysis has provided feedstock characteristic information for project developers including: substrate digestion potential; biogas and methane production; gas inhibition of different substrates; optimal substrate loading rates; pilot scale tests to estimate full scale operation outputs; and system troubleshooting. The AWM lab is a successful example of a university research resource working to improve the operation of biogas projects.

This section contains a listing of future public institution research questions. Appendix D contains a summary of Midwestern public institution research initiatives conducted in the last ten years. Appendix D is a sample of research initiatives and is not an exhaustive list. Research questions were collected during informal discussions with the same group of industry stakeholders that contributed policy recommendations.

Biogas Research Questions

- Bioenergy mapping tools for individual states. What could be developed/modeled after the Iowa DNR asset mapping project? Can other states put together resources to include information on locations of livestock facilities, wastewater treatment facilities, food processing facilities, natural gas injection hot spots, electrical distribution infrastructure, locations and volumes of co-digestion feedstocks and other relevant information?

- Biogas as a source for ammonia production. How can biogas be used to produce ammonia? A competing source for agricultural ammonia is power plants using ammonia to reduce NOx emissions in the stacks. Could agriculture biogas be a source of supplying ammonia for power plant emissions mitigation?

- Biogas compared to other renewable energy resources. What is the real value of the baseline energy provided by biogas compared to wind or solar energy?

- Biogas vehicles. How can upgraded biogas be used as vehicle fuel for farm or fleet vehicles? What equipment is necessary? What are best practices? What are the costs? What are the benefits? What models work best?

- Continued economic research on economies of scale for biogas projects. At what scale does it make sense to have a community digester concept? What are the necessary economic factors for considering a community digester model? What are the cost and benefit trade-offs for a community digester model compared to an on-farm system? What new business models could work for biogas projects? How can the ownership structure of projects be changed to minimize risk to individual agricultural producers? Could smaller farm projects receive a greenhouse gas abatement and manure benefit only without capital investments in energy generation to improve economies of scale?

- Economic impact analysis of biogas as a renewable vehicle fuel. What are the positive or negative impacts of using biogas as a renewable vehicle fuel? How does biogas compare to existing liquid renewable fuels, like ethanol or biodiesel?

- Enzyme research. What is the actual performance of enzymes added to anaerobic digesters to reduce the hydrogen sulfide content of biogas? Are these products effective? University research in this area would provide a greater level of confidence to producers interested in using one of these products instead of investing in traditional scrubbing equipment for hydrogen sulfide removal.

- Expanded co-digestion research. What organic feedstocks are best to combine with manure or other sources? What mixes yield the greatest biogas production? What model ratios of different mixes could be developed to provide guidance to future projects? Bench scale tests can help to answer these questions. One of the most important considerations for co-digestion is that feedstock supply is consistent.

- Greenhouse gas analysis of source separated organics. What is the greenhouse gas benefit or consequence for diverting source separated organics from a landfill and using a biological process, like anaerobic digestion, to break down the material and capture biogas? Is it more beneficial to leave the source separated organics in the landfill and capture biogas from the landfill?

- Pathogen research. What is the ability of anaerobic digestion projects operating at different temperatures to kill pathogens? What temperature is needed to achieve maximum pathogen destruction? What is the impact on animal health from using digested solids as bedding? What are the risks? What are the benefits?

- Performance measurements using existing protocols. How effective is the equipment of installed and research based systems? What equipment recommendations can be made to improve system performance? How do technology providers compare? Do advantages and disadvantages exist between different technology developers? An independent study would give some assurance to project owners if technology claims are accurate.

- Soil quality impacts from fertilizing crops with digestate containing multiple digested feedstocks. What co-digestable feedstocks can still be land applied? Which feedstock should be avoided if digestate is going to be used to fertilize crops? What are the impacts on soil quality over time? What are the impacts on different crop mixes?

- Standard anaerobic digester design. Could a system be designed to work for the majority of U.S. farms? Could this system be manufactured in an assembly line setting to reduce the capital costs of the system? Could a design be developed that requires less operational attention in order to work for a larger majority of agriculture producers?

Research Highlight: Iowa DNR Asset Mapping Project

The Iowa Department of Natural Resources (DNR) has recognized the enormous opportunity of turning agricultural wastes into energy and potential cost savings for the state of Iowa through wide-scale implementation of anaerobic digesters. The Iowa DNR is in the process of promoting digesters to communities that have large concentrations of livestock production and volumes of organic waste and are major energy users.

One of the main ways the Iowa DNR has been able to promote anaerobic digester projects is through the creation of the Iowa Anaerobic Digester Asset Mapping Tool. This GIS-based interactive mapping tool was designed to assist the DNR and its partners with the identification of Iowa sites that have large quantities of co-digestible feedstocks and energy-intensive industries. Mapping data sets available to date include wastewater treatment plants, confined feeding operations, open feedlots, food manufacturing facilities, rendering facilities, municipal utilities (electric and gas), biodiesel production facilities, and ethanol production facilities (in house, under construction, operational).

Iowa has the capability to become a leader in the emerging anaerobic digester industry, especially since the state has the highest methane production potential from swine and poultry layer production in the Midwest. With the new ability for farm production owners to map area supply, an increase in anaerobic digester development is possible. Iowa has implemented tools and research to put their state at the leading edge of anaerobic digestion.

To use the DNR's mapping tool, go to www.iowadnr.gov.

Conclusion

The additional development of biogas resources in the Midwest holds significant promise for our agricultural producers, processing facilities, and production industries.

Agriculture producers and agriculture-related industries are a major source of potential biogas production. Development of this resource could add economic value to our rural communities and supply a stable, steady, and versatile source of renewable energy. If the right mix of policies are developed and implemented, biogas could provide a source of renewable electricity, natural gas replacement, vehicle fuel, chemical production, and fertilizer. A strategic policy approach for scaling up biogas in the Midwest must be developed. The information presented in this report provides an overview of what is currently in place for biogas-related policy and a list of policies for further consideration. It is only the starting point in developing a comprehensive strategy for biogas development in Midwestern states.

The time is ripe for an increase in biogas development. Technology advancements in recent years have diversified ways to produce and use biogas. However, the current policy environment at the state and federal level does not recognize the tremendous resource potential from biogas. Without additional mechanisms and incentives geared towards diverse biogas utilizations and expanded ownership or management models, biogas development will struggle to grow and an opportunity will be missed to diversify our energy supply with a stable and versatile renewable resource. The Midwest has a unique opportunity to develop biogas resources; the time is ripe, the technology is ready, and the possibilities are endless. It is time for biogas to step into the spotlight and become a part of our energy future.

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Department of Commerce and Economic Opportunity, Renewable Energy Resources
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University of Illinois Center for Advanced BioEnergy Research
www.bioenergy.illinois.edu

Indiana

Indiana Office of Energy Development
www.in.gov/oed/

Purdue University, Renewable Energy Resources
www.extension.purdue.edu/renewable-energy/index.shtml

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Agricultural Marketing Resource Center, Manure Digester Biogas
www.agmrc.org/commodities__products/biomass/manure_digester_biogas.cfm

Iowa Energy Center
www.energy.iastate.edu/becon

Iowa Office of Energy Independence
www.state.ia.us/government/governor/energy

Iowa State University, Department of Agricultural and Biosystems Engineering
www.abe.iastate.edu/wastemgmt/anaerobic-treatment.html

Kansas

State Energy Office
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Michigan Department of Energy Labor and Economic Growth, Biomass Energy
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Michigan State University, Bioenergy
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Minnesota

Minnesota Office of Energy Security
www.energy.mn/gov

University of Minnesota, Dairy Extension
www.extension.umn.edu/dairy/management/manure.htm

University of Minnesota, Department of Bioproducts and Biosystems Engineering
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www.environment.umn.edu/iree

Missouri

Missouri Department of Natural Resources, Renewable Energy
www.dnr.mo.gov/energy/renewables/index.html

Nebraska

University of Nebraska-Lincoln, Livestock Manure Management
www.water.unl.edu/manure

North Dakota

North Dakota Department of Commerce, Energy Efficiency and Renewable Energy
www.communityservices.nd.gov/energy

Ohio

Ohio Biomass Energy Program
www.puco.ohio.gov/PUCO/IndustryTopics/Topic.cfm?id=4380

South Dakota

Governor's Office of Economic Development
www.sdreadytowork.com

Wisconsin

Focus on Energy, Biogas Digestion Fact Sheets and Case Studies
www.focusonenergy.com/Information-Center/Renewables/Fact-Sheets-Case-Studies/Biogas.aspx

Wisconsin Office of Energy Independence
www.energyindependence.wi.gov

Additional Resources

Association of State Energy Research & Technology Transfer Institutions (ASERTTI): Digester Performance Partnership
www.asertti.org/programs/digester/index.html

Midwest Rural Energy Council
www.mrec.org/anaerobic_digestion_text.html

U.S. EPA AgSTAR Program
www.epa.gov/agstar/index.html

Appendix D: Sample of biogas research initiatives, 2000-2010

Indiana

- Basics of Energy Production through Anaerobic Digestion of Livestock Manure. Klein E. Ileleji, Chad Martin, and Don Jones; Department of Agricultural and Biological Engineering,Purdue University; ID-406-W. http://www.extension.purdue.edu/extmedia/ID/ID-406-W.pdf

Illinois

- Anaerobic digestion of cattle waste at mesophilic and thermophilic temperatures. R. I. Mackie and M. P. Bryant. Applied Microbiology and Biotechnology Volume 43, Number 2 June, 1995, University of Illinois. http://www.springerlink.com/content/j73642lw154n6187/

Iowa

- Evaluation of Laboratory Biochemical Methane Potentials as a Predictor of Anaerobic Dairy Manure Digester Biogas ad Methane Production. Bishop, G., R. Burns, T. Shepherd, L. Moody, C. Gooch, R. Spajic. 2009. Iowa State University. Proceedings of the 2009 ASABE International Meeting, June 21-24, 2009. Reno, Nevada. http://www.abe.iastate.edu/fileadmin/www.abe.iastate.edu/extension/wastemgmt/Anaerobic_Digestion/Bishop_EvalofBMPsforAD_ASABETechPaper2009.pdf
- Anaerobic Digestion System Selection for Croatian Swine Manure. By: Spajic, R., R. Burns, L. Moody, D. Kralik. 2009. University of Iowa. Proceedings of the 44th Annual International Symposium on Agriculture. Opatija, Croatia. http://www.abe.iastate.edu/fileadmin/www.abe.iastate.edu/extension/wastemgmt/Anaerobic_Digestion/Spajic_et_al_Anaerobic_Digester_Systems_RTB.pdf
- Use of Biochemical Methane Potential (BMP) Assays for Predicting and Enhancing Anaerobic Digester Performance . Moody, L., R. Burns, W. Wu-Haan, R. Spajic. 2009. Iowa State University, Dept. of ABE, 3165 NSRIC, Ames, Iowa, 50011, USA. Proceedings of the 44th Annual International Symposium on Agriculture. Opatija, Croatia. http://www.abe.iastate.edu/fileadmin/www.abe.iastate.edu/extension/wastemgmt/Anaerobic_Digestion/Moody_et_al_Biochemical_Methane_Potential_final_short_version.pdf
- Biomass Energy Technical Note No. 1- An Analysis of Energy Production Costs from Manure Anaerobic Digestion Systems on U.S. Livestock Production Facilities. By: Beddoes, J.C., K.S. Bracmort, R.T. Burns, W.F. Lazarus. 2007. 6 Nov. 2007. NRCS-USDA. http://www.abe.iastate.edu/fileadmin/www.abe.iastate.edu/extension/wastemgmt/Anaerobic_Digestion/NRCS_Tech_Note_1_corrected.pdf
- Viability of Methane Production by Anaerobic Digestion on Iowa Swine Farms. By: Matthew Ernst, undergraduate student, Jared Rodecker, undergraduate student, Ebby Luvaga, undergraduate advising coordinator, Terence Alexander, associate scientist, James Kliebenstein, professor, John Miranowski, professor and chair, Department of Economics; Iowa State University; ASL-R1693. http://www.agmrc.org/media/cms/asl1693_C1B3959140EF2.pdf

Kansas

- Carcass Disposal: A Comprehensive Review – Anaerobic Digestion. Larry E. Erickson Chemical Engineering, Eric Fayet Chemical Engineering, Bala Krishna Kakumanu Chemical Engineering, Lawrence C. Davis Biochemistry. Kansas State University. National Agricultural Biosecurity Center Consortium, Chapter 7. http://fss.k-state.edu/FeaturedContent/CarcassDisposal/PDF%20Files/CH%207%20-%20Anaerobic%20Digestion.pdf

Michigan

- Cow-powered Farm: Exploring the Possibilities of Anaerobic Digesters. By: M. Charles Gould, Michigan State University Extension. Extension Bulletin E - 3080, September 2009. http://web2.msue.msu.edu/bulletins/Bulletin/PDF/E3080.pdf
- Anaerobic Digestion Biogas-potential Assay. By: Steven Safferman, Louis Faivor; Michigan State University, Dept. of Biosystems and Agricultural Engineering, Michigan Diary Review, October 2008. https://www.msu.edu/~mdr/vol13no4/safferman.html

Minnesota

- Changes in Microbial Community Composition Following Treatment of Methanogenic Granules with Chloroform. Hu, B., Zhou, X., Chen, S. Environmental Progress and Sustainable Energy, 28(1): 60-71. http://onlinelibrary.wiley.com/doi/10.1002/ep.10338/abstract
- The fate of genes encoding for tetracycline resistance in anaerobic and aerobic digestion. Diehl, D.L. Thesis (M.S.)--University of Minnesota, 2009. Major: Civil engineering.
- Biological Hydrogen Production with Chloroform Treated Methanogenic Granules. Hu, B., Chen, S. Applied Biochemistry and Biotechnology, 148(1-3):83-95. http://www.springerlink.com/content/v575861206513716/
- Funding on-farm biogas recovery systems: a guide to federal and state resources. Roos, Kurt Zygmunt, Hank; VonFeck, Stephanie; United States. Environmental Protection Agency. Saint Paul, Minn. University of Minnesota Extension. http://www.epa.gov/agstar/pdf/ag_fund_doc.pdf
- A Novel Use of Anaerobically Digested Swine Manure to Potentially Control Soybean Cyst Nematode. Xiao, J., J. Zhu, S. Chen, W. Ruan, and C. Miller. J. Environ. Sci. & Health Part B B42(6): 749-757. http://www.informaworld.com/smpp/content~db=all~content=a781325429
- Control of the Soybean Cyst Nematode Using Anaerobically Digested Liquid Swine Manure. Xiao, J., J. Zhu, S. Chen, W. Ruan, and C. Miller. Journal of Nematology 39(1): 73-73 (Abstract). http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2586534/
- Pretreatment of Methanogenic Granules for Immobilized Hydrogen Fermentation. Hu, B., Chen, S. International Journal of Hydrogen Energy,32: 3266-3273. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V3F-4X6DBFS-1&_user=10&_coverDate=10%2F31%2F2009&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1389029620&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_use
- Anaerobic Digestion for Energy and Pollution Control. Goodrich, P. R., Schmidt, D. R.. ASAE Annual International Meeting / CIGR XV World Congress, July 28-31, Chicago, IL, Paper No. 024188, ASAE, 2950 Niles Road, St. Joseph, MI (on CD-ROM). http://www.cigrjournal.org/index.php/Ejounral/article/view/575

Missouri

- Generating Methane Gas From Manure. By: Charles D. Fulhage, Dennis Sievers and James R. Fischer, Department of Agricultural Engineering. http://extension.missouri.edu/publications/DisplayPub.aspx?P=G1881
- Energy from agriculture. Clausen, E. C.; Million, D. L.; Park, E. L.; Gaddy, J. L. University of Missouri. In: Energy crisis: Two years progress towards self-reliance; Proceedings of the Second Annual UMR-MEC Conference on Energy, University of Missouri, Rolla, Mo., October 7-9, 1975. (A76-42476 21-44) North Hollywood, Calif., Western Periodicals Co., 1976, p. 135-142. http://adsabs.harvard.edu/abs/1976ecty.proc..135C

Nebraska

- What is an Anaerobic Digester? By: Chris Henry, Extension Engineer; Rick Koelsch, Livestock Bioenvironmental Engineer; University of Nebraska – Lincoln. Manure Matters, Volume 7, Number 10. http://files.harc.edu/Sites/GulfcoastCHP/Publications/WhatIsAnaerobicDigestion.pdf

North Dakota

- Feasibility of a Cattle Feedlot/Large Dairy Co-located with the Blue Flint Ethanol Plant. By: Greg Lardy, Scott Pryor (NDSU), Eric DeVuyst, Ron Wiederholt, Wally Eide, J. W. Shroeder. On-line article. http://www.ndsu.edu/aben/research/research_areas/environmental_resources_management/feasibility_of_a_cattle_feedlotlarge_dairy_co_located_with_the_blue_flint_ethanol_plant/
- Energy Integrated Dairy Farm System in North Dakota. Pratt, G.; Lindley, J.; Hirning, H.; Giles, J., North Dakota State Univ., Fargo. OSTI ID: 7174918; Legacy ID: DE87005833. http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=7174918

Ohio

- Ohio Consumers Profiles, Willingness to Pay, and Attitudes Regarding Anaerobic Digestion on Dairy Farms. THESIS By Daniel J. Sanders, B.S. The Ohio State University, 2009. http://etd.ohiolink.edu/send-pdf.cgi/Sanders%20Daniel%20J.pdf?osu1242830489

- Anaerobic Digestion of Agricultural and Food Waste Biomass for the Efficient Production of High Quality Biogas. Project director: Schanbacher, F.L., Animal Sciences, Ohio State University. http://www.reeis.usda.gov/web/crisprojectpages/200286.html

- PowerPoint presentation: Anaerobic Digestion: Overview & Opportunities. Floyd Schanbacher, Director, OARDC Third Frontier, Biomass to Energy Research Program, Ohio Agric. Res. & Dev. Center, The Ohio State University. http://www.chpcentermw.org/pdfs/090407_Ohio/Schanbacher.pdf

- OARDC Green Energy Technology Key to New $2 Million Third Frontier Grant: A recent $2 million grant awarded by the state of Ohio's Third Frontier Advanced Energy Program to boost the amount of biogas produced from waste has at its core technology developed by Ohio State University's Ohio Agricultural Research and Development Center (OARDC). The main purpose of the award is to help commercialize an integrated anaerobic digestion system dubbed iADs, which can cost-effectively produce clean energy from both solid and liquid organic wastes through anaerobic digestion. The iADs is an innovative (patent-pending) technology developed by Yebo Li, a biosystems engineer in OARDC's Department of Food, Agricultural, and Biological Engineering and a specialist with OSU Extension. The system is called "integrated" because it combines a liquid biodigester (which processes wastes such as manure and sewer sludge) and Li's "solid-state" digestion technology (which allows for the production of methane from various sources of cellulosic biomass, such as yard trimmings and crop residue). http://www.oardc.ohio-state.edu/5526/OARDC-Green-Energy-Technology-Key-to-New-$2-Million-Third-Frontier-Grant.htm

South Dakota

- No specific anaerobic digestion research initiatives to include at this time.

Wisconsin

- Integrated Catalytic Conversion of -Valerolactone to Liquid Alkenes for Transportation Fuels. By: Jesse Q. Bond, David Martin Alonso, Dong Wang, Ryan M. West, James A. Dumesic. Department of Chemical and Biological Engineering, University of Wisconsin-Madison, Madison, WI 53706, USA. Science 26 February 2010: Vol. 327. no. 5969, pp. 1110 – 1114; DOI: 10.1126/science.1184362. http://www.sciencemag.org/cgi/content/abstract/sci;327/5969/1110?maxtoshow=&hits=10&RESULTFORMAT=&fulltext=university+of+wisconsin&searchid=1&FIRSTINDEX=0&sortspec=date&resourcetype=HWCIT

- Making the Most of Manure. By Bryan Sims, Biomass Magazine, October 2007 Issue. Complaints from odor-offended neighbors and a desire to reduce greenhouse gas emissions have prompted some dairy farmers to integrate anaerobic digestion systems into their operations. Although it's not for everyone, using manure to generate power and produce a nutrient-rich soil amendment is something that should seriously be considered. http://www.biomassmagazine.com/article.jsp?article_id=1296

- Anaerobic Digesters and Methane Production...Questions that need to be asked and answered before investing your money. Prepared for Discovery Farms under funding by UW-Extension. Developed by Dennis Frame and Fred Madison, co-directors; Wes Jarrell, senior scientist; Justin Johnson and Sarah Steenlage, technical assistants; and Shannon Hayes, communications coordinator. http://bio.uwex.edu/library/documents/methanepubbw.pdf

- Wisconsin Agriculture Biogas Casebook. By: Joe Kramer, Energy Center of Wisconsin. As of July 2008, there were 17 farms with operating anaerobic digester systems in Wisconsin. This number includes five farms that have two digesters bringing the total digesters in the state to 22. All of the operational systems are on dairy farms. The farms with digesters are spread throughout the state. http://bio.uwex.edu/library/documents/2008BiogasCaseStudy.pdf

- Temperature Phased Anaerobic Digestion System Monitoring Project at Tinedale Farm. John F. Katers, Assistant Professor of Natural and Applied Sciences, University of Wisconsin-Green Bay and Joe Schultz, Graduate Student in Environmental Science and Policy, University of Wisconsin-Green Bay. http://www.mrec.org/pubs/Tinedale_Farm_Monitoring_Study_Final_Report.pdf

- Phosphorus forms and extractability in dairy manure: A case study for Wisconsin on-farm anaerobic digesters. By: Güngör, Kerem; Karthikeyan, K.G. Biological Systems Engineering Department, University of Wisconsin-Madison, 460 Henry Mall, Madison, WI 53706, United States. Bioresource Technology, Jan2008, Vol. 99 Issue 2, p425-436, 12p; DOI: 10.1016/j.biortech.2006.11.049; (AN 27274333). http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V24-4N0PFRV-1&_user=10&_coverDate=01%2F31%2F2008&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=207441949a5a960e1d379809cd4a8481

- Probable Phosphorus Solid Phases and Their Stability in Anaerobically Digested Dairy Manure. By: K. Güngör, K. G. Karthikeyan. Biological Systems Engineering Department, University of Wisconsin-Madison. Bioresource Technology Volume 99, Issue 2, January 2008, Pages 425-436; doi:10.1016/j.biortech.2006.11.049. http://asae.frymulti.com/abstract.asp?aid=19188&t=2

Appendix E: Image Credits

1. Page 12, photo in text, Fergus Falls Wastewater Treatment Plant.
2. Page 19, Linköping project highlight, Swedish Biogas International
3. Page 20, Flint, Michigan project highlight, Swedish Biogas International
4. Page 21, Central Disposal System project highlight, Dairyland Power Cooperative and Perfect Circle Corporation
5. Page 24, Jer-Lindy project highlight, Jerry and Linda Jennissen
6. Page 25, Fergus Falls project highlight, Fergus Falls Wastewater Treatment Plant
7. Page 25, photo in text, Fergus Falls Wastewater Treatment Plant
8. Page 26, photo in text, Dairyland Power Cooperative
9. Page 27, Kluthe project highlight, Danny Kluthe/Cuming County Public Power District
10. Page 30, Amana project highlight, Amana Farms, Inc.
11. Page 31, Five Star project highlight, Dairyland Power Cooperative
12. Page 32, Haubenschild project highlight, the Minnesota Project
13. Page 34, photo in text, Phase 3 Renewables
14. Page 35, CVPS project highlight, Central Vermont Public Service
15. Page 48, Hilarides project highlight, Phase 3 Renewables
16. Page 50, Scenic View Dairy project highlight, Phase 3 Renewables