Wisconsin Biogas and Feedstock Survey Final Report

OEI
Wisconsin Office of Energy Innovation

Extension
UNIVERSITY OF WISCONSIN–MADISON

Center for Land Use Education
College of Natural Resources
University of Wisconsin-Stevens Point

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PREFACE AND ACKNOWLEDGMENTS

This study focuses on biogas feedstock and industry status, challenges and opportunities in Wisconsin as a follow up to a previous study conducted by Public Service Commission of Wisconsin, Office of Energy Innovation (OEI) in 2016. This project was funded by OEI from its U.S. Department of Energy (US-DOE) State Energy Program Formula funds (Federal Award Identification Number: DE-EE0008669).

On behalf of OEI, a team from the University of Wisconsin-Stevens Point (UWSP) led by Professor Shiba Kar conducted this survey-based study. UWSP team members included Karen Blaha (UWSP Outreach Specialist), Logan Brice (LTE staff), and Marcie Nelson (undergraduate student). The UWSP team worked closely with OEI staff on finalizing the biogas facility contact lists and designing the survey questions. The regular meetings with OEI staff Tom Nowakowski, Kishan Panduranga, and Joe Pater supported the successful completion of this project. The conclusion and opinions in this report are those of the UWSP team and not OEI or U.S. Department of Energy.

We acknowledge the feedback and suggestions that we received from several biogas facility experts in Wisconsin including: Tim Baye, Jessica Niekrasz, Joe Kramer and Mathew Christman. Their feedback helped us refine the survey questions. We also appreciate Brian Langolf at University of Wisconsin-Oshkosh, Jessica Niekrasz at Clean Fuel Partners, and Mark Hill at Novilla RNG for their help in pretesting the survey and providing feedback.

Thank you to Professor Stephanie Lansing and her graduate student Carlton Poindexter at the University of Maryland for sharing their state-focused biogas study survey questionnaire that was very useful as background for this study. Special thanks to Mathew Christman, Wisconsin Biogas Council who helped disseminate the information about this survey and connect us with facilities to gather more information and photos to include in the report. We are also grateful to many facilities who shared their facility photos to use in this final report.

Finally, we thank survey respondents who took time to share valuable information for the successful completion of this project.

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Wisconsin Biogas and Feedstock Survey Final Report

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Executive Summary

This report is intended to quantify and support the biogas-related efforts in Wisconsin. Based on a new statewide Biogas Feedstock and Industry Survey, this report serves as a follow-up to a previous Biogas Survey Report conducted by Public Service Commission of Wisconsin, Office of Energy Innovation (OEI) in 2016. This current study will support Wisconsin's Clean Energy Plan (to be released in 2021), a plan resulting from the Governor's Task Force on Climate Change Report (State of Wisconsin, 2020).

The survey findings included in this report highlight the current status of biogas facilities including operation, maintenance, and sources of biodigester feedstocks. Survey results also identify biogas and energy production, process by-products, as well as industry opportunities and challenges, potential supportive policies and recommendations.

In partnership with OEI staff, the University of Wisconsin-Stevens Point (UWSP) team designed a survey and sent it to more than 300 Wisconsin biogas facilities related to biogas operations, including dairy and agricultural operations, wastewater treatment facilities, landfills, industrial and food processing facilities. The data collection included both electronic and mail-in survey questionnaires. Eighty-two respondents participated in the survey providing valuable data and information. The findings from this study can be used to address the barriers and challenges of biogas industries and promote biogas production and use in Wisconsin.

Photo 1: Dairy Biogas Anaerobic Digester Facility, Clean Fuel Partners, LLC, Dane, WI

Key Findings

FACILITIES IN WISCONSIN

- Based on the study results, the majority of the biodigesters in Wisconsin are installed in municipal wastewater treatment facilities (WWTFs) followed by dairy and agriculture sector-based biodigesters, food processing and industrial waste based biodigesters and landfills biogas systems.
- Most of biodigester facilities have been built within last 50 years (1970 to 2020) with a large number of biodigester additions in last decade (2010-2020). However, a small percentage of installed biodigesters are currently not operational.
- Odor control, enhancing renewable energy production and added facility income are the primary motivators for adopting on-site biodigesters.
- On average, biodigesters cost $3 million or more to install, however; small-scale biodigesters can be installed for less than $100,000.
- A large number of biodigester facilities were built without any grant support. Among the facilities which received grants, most of them received 10 to 30% grant funding to offset their installation costs.
- On average, most of the biodigester facilities have volume capacity of 2 million gallons to handle the slurry. Average biodigesters in Wisconsin have 42,000 cubic feet of gas storage capacity and daily rated gas production volume capacity of 300,000 cubic feet.

SOURCES AND USE OF FEEDSTOCK

- Municipal wastewater is the largest source of biogas feedstock in current biodigester facilities. Manure from dairy was the second largest source of biodigester feedstock.
- Biodigesters in many WWTFs use industrial high strength wastewater as supplemental feedstock. Additional supplemental feedstocks include those received from food processing industries, restaurants, and breweries.
- Most of the feedstock tends to come from within a 20 miles radius of the biodigester facilities although some facilities collect from a distance of 50 miles or more.
- Top challenges for feedstock acquisition and use include storage, inconsistent timing and frequency of feedstock supply, and contaminants in feedstock.

BIODIGESTER OPERATIONS AND MAINTENANCE

- Most biodigesters in Wisconsin employ 1 to 5 staff to support their operation and maintenance.
- The annual cost of biodigester operation and maintenance varies—half of the respondents reported costs below $100,000 while others reported costs of $150,000 or more. Most of the biodigesters take cost effective measures in their operations that include maintaining the heat pump and exchanger, using heat for process, managing the loading of feedstocks, and managing chemical processes and microbes.

- Only a few biodigester facilities currently have infrastructure to inject refined biogas into the natural gas pipeline.
- Major challenges in operation and maintenance of the biodigesters include: cleaning up the biogas for onsite use, generator malfunction, foaming, maintaining quality and quantity of the biogas, and overall cost of operations.

PRODUCTION AND END USE

- Depending on the size and capacity of the biodigesters, the daily production of biogas varies from 25,000 cubic feet to more than 500,000 cubic feet.
- Many biodigester facilities use the biogas that they produce as process heat and for heating their facility.
- Many biodigester facilities produce electricity using the biogas while a small percentage of biodigesters have cogeneration facility to produce heat and electricity together.
- Most of the biodigester facilities generate co-products such as fertilizers, composts, bedding for livestock, and waste heat recovery for space heating.
- Most of the biodigester facilities have a current nutrient management plan to comply with the regulations and environmental issues.

NON-OPERATIONAL BIODIGESTER FACILITIES

- A small percentage of existing biodigester facilities in Wisconsin have become non-operational. The reasons for having a non-operational biodigester include: not making economic sense, not having enough time or personnel, and not having a large enough system to produce biogas.
- Top challenges operating a biodigester include small-scale of production, low electricity rate contract, lack of knowledge on relevant policy and regulations, permitting issues, financing, and lack of expertise and help in grant writing process for funding.
- The survey respondents requested more grant funding opportunities to offset capital cost of biodigester installation, and supportive policies and incentives to promote the biogas industry in Wisconsin.

POLICIES AND CHALLENGES

- Major challenges in adopting a biodigester include permitting, waste contracts, nutrient management concerns and regulations, generator commissioning, and grant writing.
- Assistance that might be helpful include support from contractors, utilities and vendors, funding support from state and federal sources, help with the grant writing process and more support from state and local officials.

- Several policies and practices would have been helpful for biodigester facilities include: more specific federal and state level incentives and grant funding opportunities, higher prices for electricity generated from biogas and sold to utilities, assistance in receiving renewable energy credits, and less stringent permitting requirements.
- A very small percentage of the biodigester facilities have power purchase agreements with their utilities and most of those agreements are set to expire by 2023.
- A majority of the biodigester facilities in Wisconsin (who sell electricity) receive less than $0.09/kWh or less electricity rate, however; many of them prefer a higher rate of electricity that could help them reach the break-even or start making profit out of biogas operations.
- Many of the existing biodigester facilities support having a state-level mandate on their electricity rate.
- Majority of the biodigester facilities suggest policy mandating food diversion from landfills and national renewable fuel standard policy to assist biogas industries.
- Most of the biodigester facilities are likely to invest in another biodigester system.
- When considering building another biodigester, many facilities would like to make changes that include: better handling, mixing, separating and scrubbing systems, adopting better heating system, changing generator capacity, having ability to better manage nutrients and substrates, and having renewable natural gas injection capability.
- Most of the facilities work closely with Wisconsin Department of Natural Resources (WDNR) and Wisconsin Focus on Energy program to operate successfully.
- For those facilities who indicated interest in receiving assistance, the most named organizations included: Focus on Energy, American Biogas Council, Wisconsin Biogas Council and University of Wisconsin-Madison Division of Extension.
- Types of assistance that the facilities are interested in receiving include: financial, technical, training, and supportive changes in state policies.

RECOMMENDATIONS AND FUTURE OPPORTUNITIES

Challenges identified in this study include: permitting, generator commissioning, nutrient management regulation, assistance from contractors or vendors, lack of support for funding and investments, net metering, and availability of renewable energy credits.

Recommendations to address the challenges and ensure a sustainable approach and economical operation of the biodigester facilities in Wisconsin, include:

- Ensuring adequate and supportive policies, and other financial incentives.
- Helping secure viable project financing and facilitate more investment options to stimulate the growth of biogas facilities.

- Removing barriers to selling electricity or biogas to utilities or interstate producers/ suppliers that may include a better net metering policy and facilitating more options for injecting into a natural gas pipeline.
- Supporting cost-effective and safe operation of biogas electricity generators.
- Establishing favorable environmental regulatory compliance standards.
- Strengthening organizational partnerships and inter-sectoral collaboration to enhance education and outreach efforts, information sharing and public awareness.

Biogas is a potential solution to help meet sustainability goals of Wisconsin communities, farms and industries that are focused on renewable energy and alternative fuels. Policy consensus can help address biogas industry challenges and utilize the full potential of strengthening local energy security, a stronger economy, a cleaner environment, and improved health in Wisconsin.

Photo 2: Manure Anaerobic Digester Facility, EnTech Solutions in partnership with Northern Biogas, Middleton, WI

Background

Biogas, a clean renewable gas, can be produced from various local organic waste materials including food waste, agricultural residues and animal manure, energy crops, industrial organic waste, and municipal sewage sludge. Biogas production involves a natural process called “Anaerobic Digestion” (AD) in which bacteria and other microorganisms break down and digest carbon rich organic materials in the absence of oxygen. This process generates a mixture of primarily methane and carbon dioxide, called biogas (EPA, 2021; Kar, 2018). Typical biogas contains two-third of methane, and about one-third of carbon dioxide with a small percentage of other gases such as hydrogen sulfide and carbon monoxide. (EIA, 2021). Biogas can be used to produce heat and/or electricity. This gas can also be upgraded into bio-methane by removing carbon dioxide and other gases. Bio-methane is also called renewable natural gas (RNG) and injected into natural gas pipelines if the infrastructure is available. RNG can also be compressed and used as fuels for vehicle engines called compressed natural gas (CNG).

Biogas has multiple benefits that include providing local energy and cleaner environment, improving public health, diversifying facility income and creating local jobs to strengthen local economy.

Wisconsin is one of the early adopters and leading states in the nation to produce renewable energy from anaerobic digestion systems. The Wisconsin Biogas 2016 survey report identified 136 operating anaerobic digester systems in the state that include digesters using municipal wastewater, industrial wastewater, animal manure and other agricultural residues as well as 35 operational landfills with biogas capture systems (PSC, 2016).

A wide range of available feedstock waste, the size of dairy farms and the presence of various food processing industries make the state an ideal candidate for more biogas production (Wisconsin Biogas Initiative, 2011). Methane based biopower generation potential is much higher if crop and wood-based biomass residues are also considered (NREL, 2013). Based on the estimated amount and type of available waste materials, the American Biogas Council (2019) estimates that 1,341 new biogas projects could be developed in Wisconsin that can create about 36 thousand jobs and reduce carbon emissions significantly. Wisconsin can take advantage of the full potential of utilizing these local wastes and other organic residues to produce biogas that can be used to generate local renewable heat and electricity.

The Public Service Commission of Wisconsin (WPS) - Office of Energy Innovation (OEI) and University of Wisconsin-Stevens Point (UWSP) conducted this statewide Biogas Feedstock and Industry Survey that serves as a follow-up to OEI’s Biogas Survey Report (WPS, 2016). More than 300 Wisconsin facilities including dairy and agricultural farms, wastewater treatment facilities, industrial and food processing facilities, and landfills, were asked to participate in the study. This report includes the findings based on the responses from biogas facilities and identified key issues to address the barriers and challenges of biogas industries and promote biogas production and use in Wisconsin.

Study Purpose

The purpose of this study is to assess and document current status of the biogas industries, evaluate impacts of relevant policy and incentives and current challenges that the biogas facilities face. This survey study assessed and explored the status, barriers, and challenges of biogas facilities throughout Wisconsin. Respondents' answers to the survey questions helped us better understand biogas facilities to develop a detailed Biogas report. The findings from this study will be used to address barriers and challenges of biogas industries and promote biogas production and use in Wisconsin.

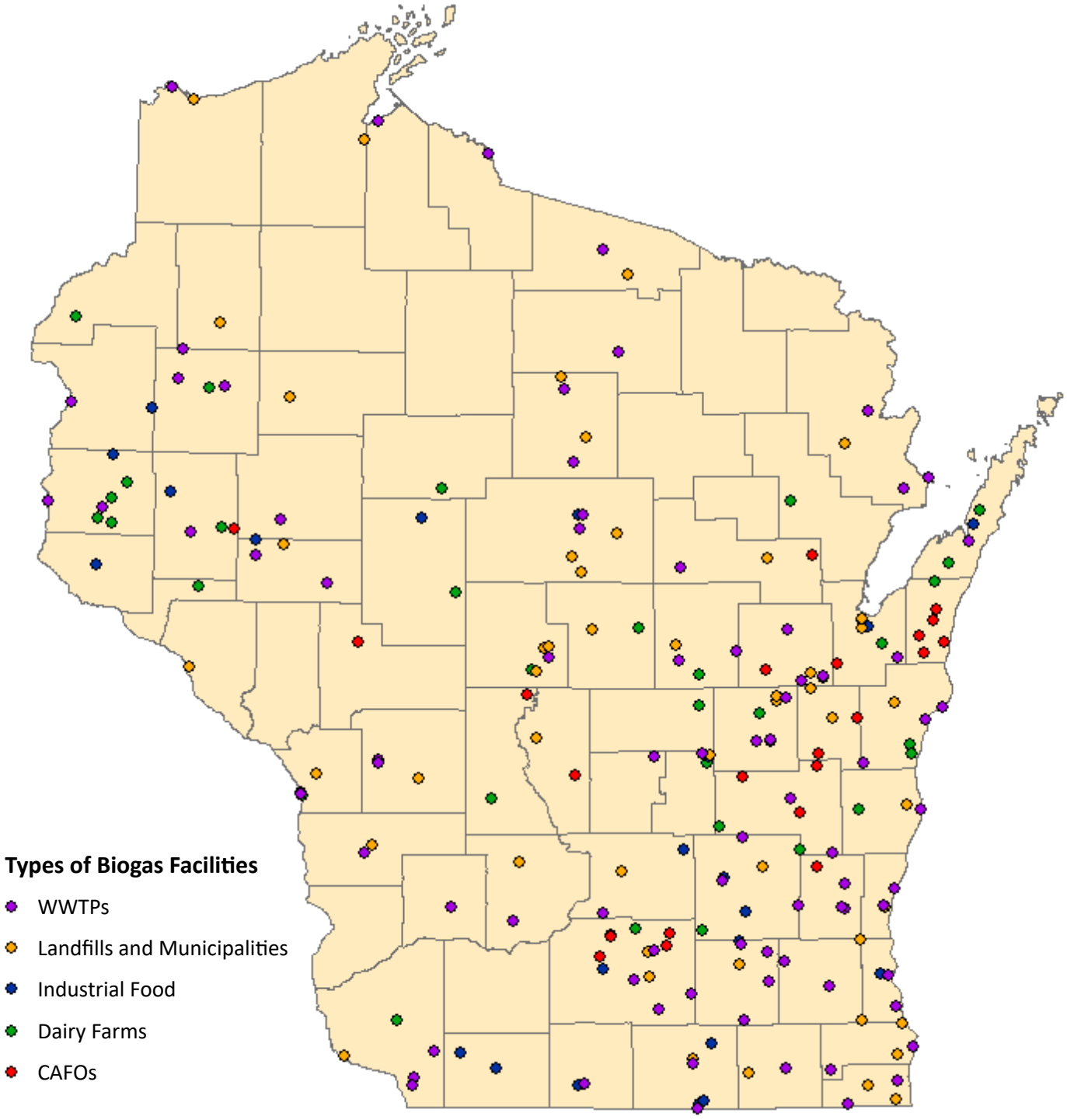
Objectives:

- Explore and assess the status, barriers and challenges of biogas facilities in Wisconsin.
- Gain a better understanding of the biogas facilities to promote biogas productions and use.

Scope and Timeframe

This study focuses on all biogas facilities in Wisconsin. Based on a previous list of biogas facilities provided by OEI, we sent the survey to 318 existing (operational and non-operational) biogas facilities and about 300 potential industries who might consider biodigesters for their facilities. We received responses from 82 facilities and this report is based on those survey responses. The study was conducted between October 2020 and March 2021.

Photo 3: High strength equalization tank with truck, Waste Water Treatment Facility, Stevens Point, WI



Map 1: Wisconsin biogas facilities on-site

October 2020			
Oct	Survey drafts developed in Qualtrics with input from OEI		
November			
Nov 2 - 17	Survey sent to 7 facility managers/ operators for review		
December			
Dec 9	Qualtrics, electronic survey sent to 187 valid emails	Dec 21	Electronic reminder to no responses
January 2021			
Jan 6	Paper surveys sent to 68 facilities with invalid emails	Jan 8	2nd electronic reminder sent to no responses
Jan 21	Electronic survey sent to 2nd list of 202 valid emails		
February			
Feb 2	229 paper surveys sent to electronic and paper survey no responses	Feb 9	Electronic reminder sent to 2nd list of 202 valid emails
Feb 10	Postcard reminder to initial electronic and paper survey no responses	Feb 19	Reminder sent to 11 electronic surveys in progress
Feb 26	Electronic reminder sent to 5 surveys in progress		
March			
Mar 10	Completed input from paper responses & closed survey	Mar	Data collection & analysis
April			
Apr	Report writing		

Figure 1: Wisconsin Biogas and Feedstock Survey Data Collection Timeline

Data Collection

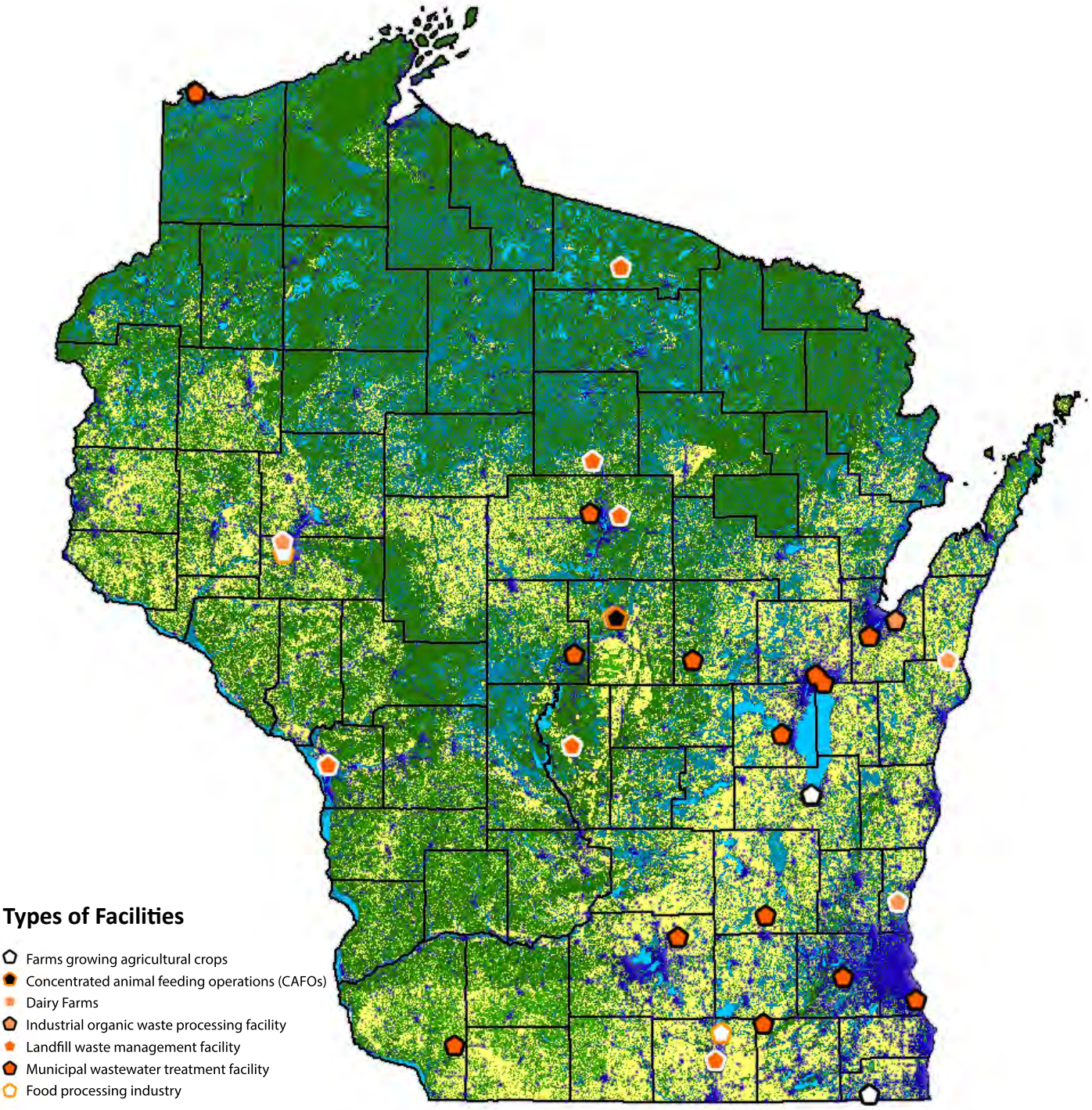
Survey Methods

The survey questionnaire was designed to use both online and paper-based survey instruments. The final survey questionnaire was sent to distribution lists provided by Wisconsin Office of Energy Innovation (OEI) via Qualtrics (online) and mailing printed surveys from November 2020 to February 2021. The survey took approximately 15-20 minutes to complete. The online survey recipients were assured that if they were unable to complete the survey in one sitting, they would be able to stop and resume at a later time. The participation of the respondents in this study was completely voluntary. The survey participants were given the opportunity to provide their email at the end of the survey to receive the study results. Contact attempts were made via telephone calls to connect with the respondents who were unreachable by the above methods. Virtual tours and one-on-one meetings with several biogas facility owners helped gain more insights about the biogas industry, verify survey responses, and write this report. Specific activities took place in survey questionnaire design, testing and implementation to collect the data that we describe with timeline in Figure 1.

The UWSP team worked closely with the OEI staff on finalizing the biogas facility contact lists and designing the survey questions. The initial contact list of biogas related facilities was received from OEI. Email addresses were verified by project staff before distribution via Qualtrics. A master contact list was created by integrating lists from select stakeholder biogas categories. The total distribution through Qualtrics and the paper survey was 318 individual surveys. The total number of bounced and returned surveys was 58. A second distribution list (299 contacts) was provided by OEI after the first Qualtrics survey was sent out. Email addresses in this list were not verified by either project staff or OEI. One round of survey was sent to those 299 email addresses and 94 email addresses bounced. The second distribution was intended to help improve the low response rate and we received additional responses. Total of 82 recorded responses included responses from Qualtrics and mailed printed completed surveys. The responses from the printed surveys were entered into Qualtrics version of the survey as they were received.

SURVEY QUESTIONNAIRES

The survey questionnaire included relevant questions in multiple sections: General Questions, Biogas Facility and Feedstock, Operations and Maintenance, Production and End Use, and Challenges and Policies. General section addressed questions on type and ownership of the facilities. The next section asked questions about the facility installation, capacity, motivating factors and feedstock use. The Operations and maintenance section included questions regarding maintenance issues, relevant costs and personnel need for smooth operation of the facilities. Production and end use section focused on the kind of product they produce and their end use. Questions in the policies and challenges section were intended to examine the policy issues, current barriers and challenges and identifying supportive policies and opportunities.



Map 2: Survey response locations by zip code or IP address

Study Findings

Over one-third of the survey respondents were associated with Municipal Wastewater Treatment Facilities. A similar number of total responses were also received from farm-based biodigester facilities. Among those farm-based facility responses, most of the respondents were affiliated with dairy farms (20% of total responses) followed by responses from agricultural crops and other livestock sectors such as consolidated animal feeding operations (CAFOs). The remainder was largely landfill waste management facilities (15%) with a few food and industrial organic waste processing facilities (Figure 2; Map 2).

Out of the total 82 survey respondents, almost three-quarters of all respondents identified themselves as facility managers. Just under a quarter of respondents indicated that they were the owners of the biodigester facility. Less than 5% of participants were either the biodigester operators or contractors (Figure 3).

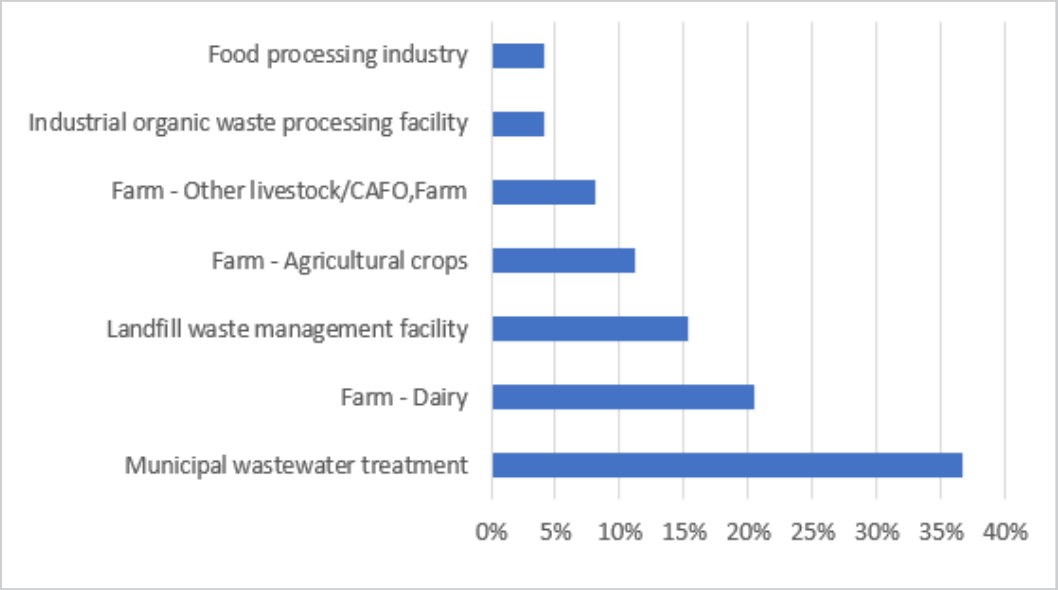


Figure 2: Respondent's affiliation with different types of biodigester facilities

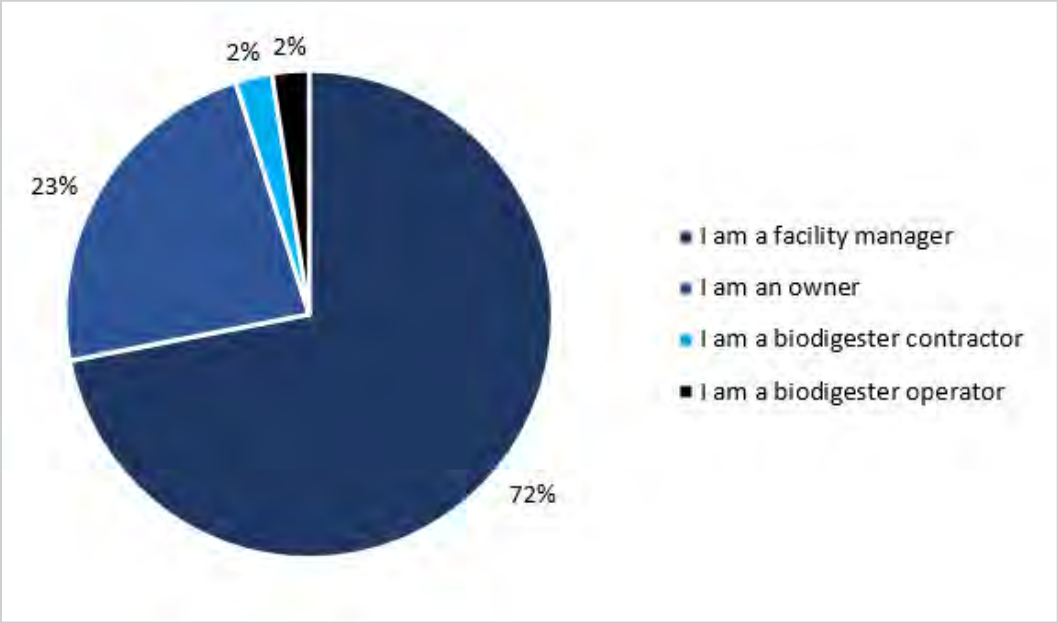


Figure 3: Role in the biodigester facility operation by percent of total respondents

Less than two-thirds or 52 total respondents were associated with a biodigester facility actively producing biogas (Figure 4). Of those actively producing, a majority of them were related with wastewater treatment or farm related biodigester facilities.

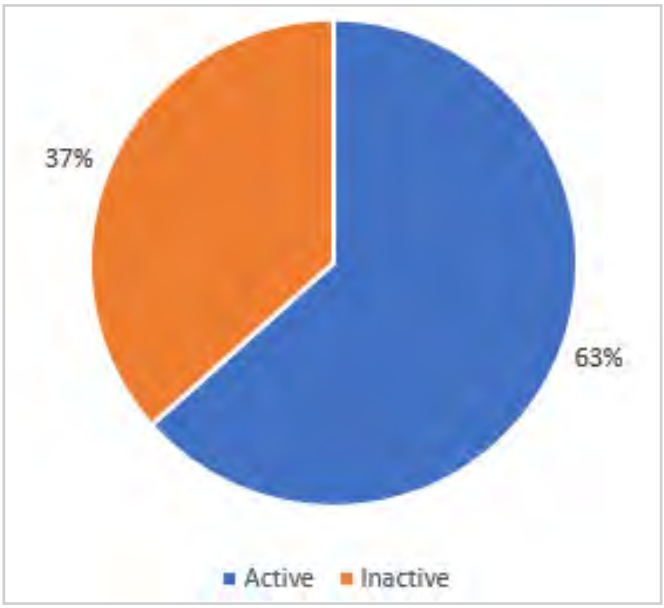


Figure 4: Active vs inactive biodigester facilities

Biogas Facility and Feedstock

BUILDING BIOGAS FACILITIES

About 49 facilities reported the year their biodigester was commissioned to start operation. Just over 30% of facilities were commissioned during 2010 - 2020. This decade had the largest number of facilities begin producing biogas. The second highest number of facilities were built and commissioned during 1970 - 1980. One to two biodigesters were commissioned almost every year after that (Figure 5; Appendix B).

There were 148 responses from 82 survey participants regarding motivation for adopting biogas facilities (Figure 6). Nutrient management and/or odor control were the top motivations for installing a biodigester among respondents. A close second, the addition of renewable energy to the facility was a top motivator for building a biodigester. The third highest responses were a combination of biosolid treatment/resource recovery and improving public relations/education. Income from sales of electricity or biogas was

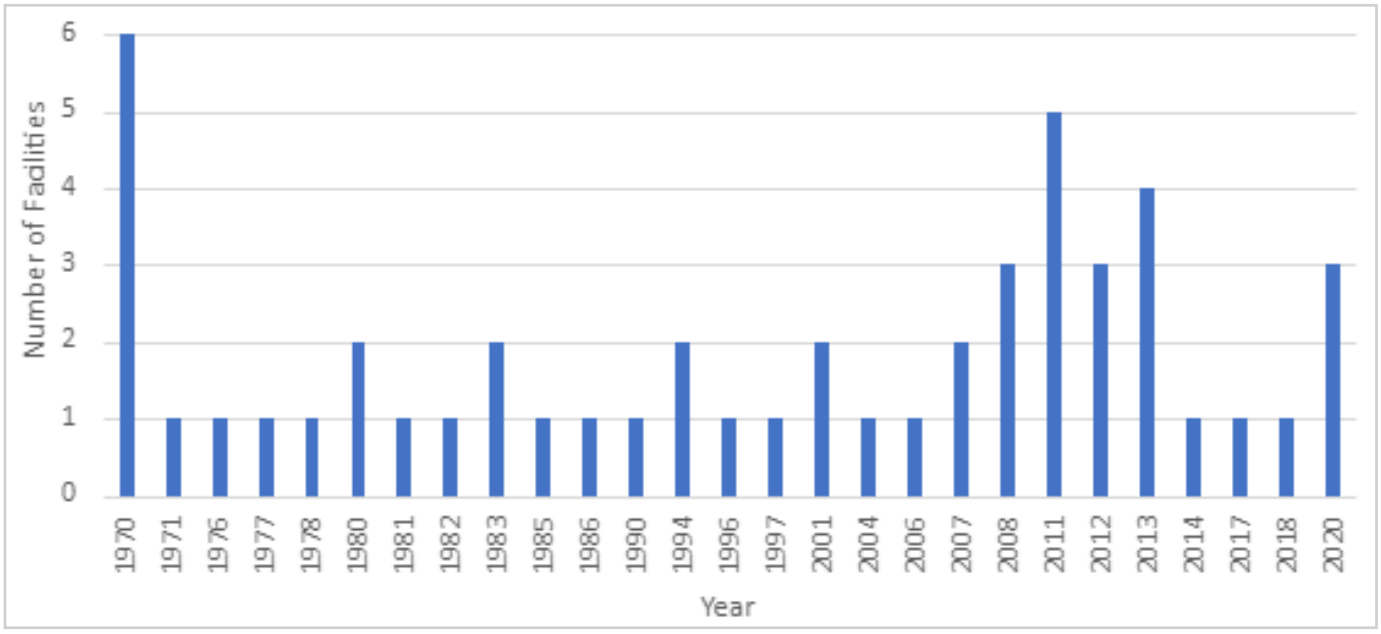


Figure 5: Year the biodigester was commissioned to begin operation

another highly selected motivation for building a biodigester.

Building biodigesters seemed to play an important role for the facility operations. Most of the respondents indicated that their biodigester was important to the success of their operation. More than three-fourth of the respondents believe that their biodigester is extremely important or very important, while less than 10% indicate that it is not important (Figure7).

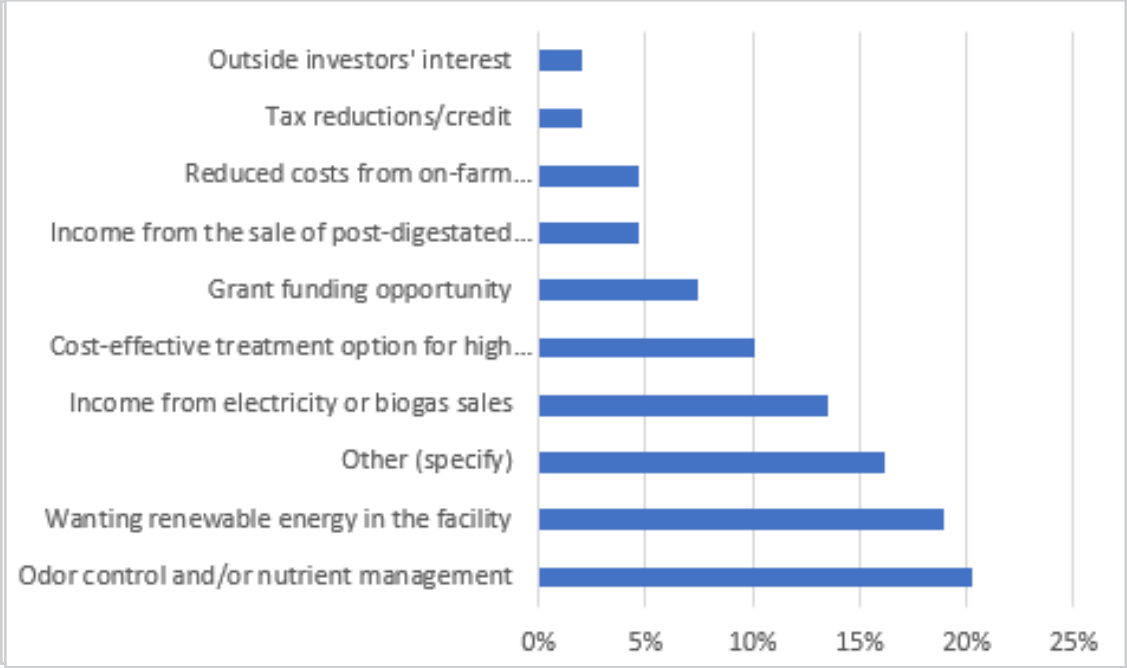


Figure 6: Top motivation for building a biodigester

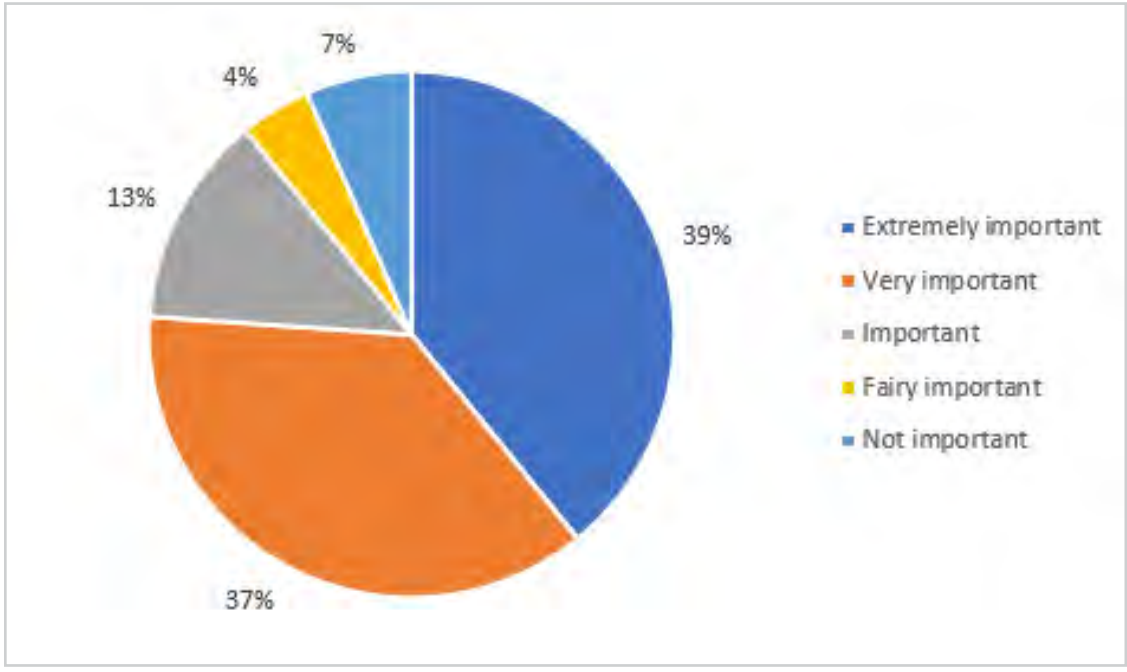


Figure 7: Importance of biodigester in facility operations

Over 75% of facilities believe that their biodigester is an important source of income for their farm or facility, while less than 25% believe that their biodigester is important for income (Figure 8).

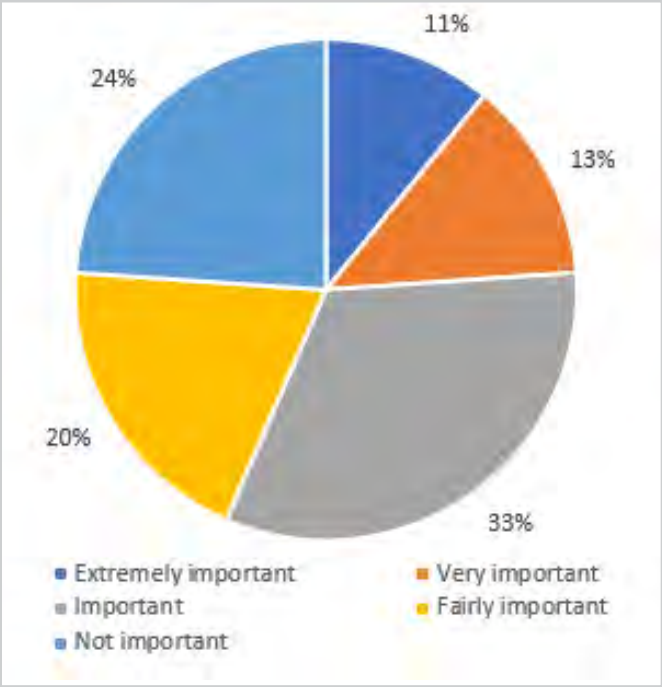


Figure 8: Importance of biodigester in facility income

The study also finds that a majority of most biodigesters cost over 3 million dollars to build depending on the scale of the facilities. However, many reported the cost to be between $500,000 to $3 million. A few respondents indicated that small scale biodigesters could be built with the cost less than $100,000 (Table 1).

Table 1: Total cost of installing a complete biodigester

Cost	Count	Percent
Less than $100,000	2	5%
$500,001 - $1,000,000	3	8%
$1,000,001 - $3,000,000	10	26%
$3,000,001 - $5,000,000	11	29%
More than $5,000,000	12	32%
Total	38	

Nearly half of facilities were built by a biodigester company without a monitoring or maintenance contract. The other half were a closely equal split between self-built biodigesters and facilities built by a biodigester company with a monitoring or maintenance contract. Out of 36 respondents, about 40% of the facilities received no grant funding for the financing of their biodigester. Over one-quarter of facilities received between 1-10% of their total biodigester cost in form of grant funding. About 20% of facilities had between 21-30% of their total costs offset by grants. Only about 12% facilities reported that above 30% of their cost was offset by grants (Figure 9).

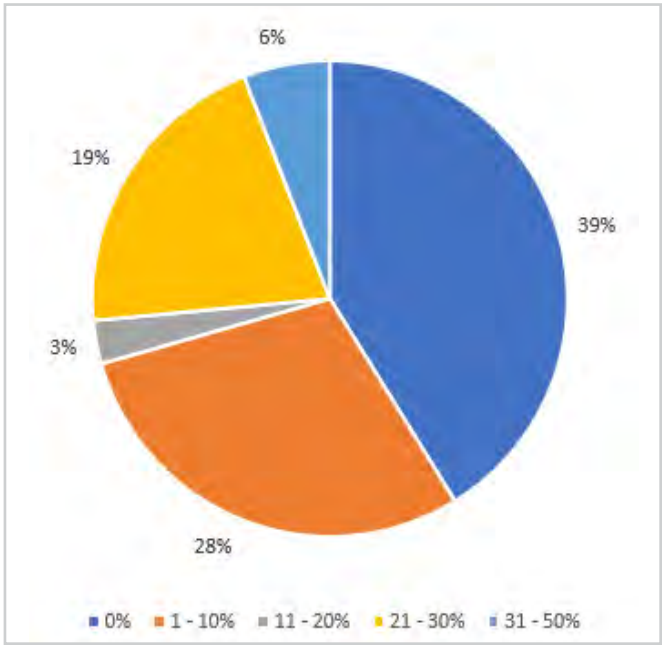


Figure 9: Percent of biodigester costs offset by grants

Based on the numbers reported by the respondents, the capacity of the biodigester facilities (the maximum amount of slurry the plant can hold) ranged between 80,000 and 8 million gallons with an average of about 2 million gallons. The gas storage volume (the amount of gas it can hold when full of slurry) ranged between 500 and 175,000 cubic feet, with an average of 42,000 cubic feet.

The rated daily gas production volume (the amount of gas the plant was designed to produce each day) ranged between 200 to 1.7 million cubic feet, with an average of about 300,000 cubic feet (Table 2).

Table 2: Reported capacity of biodigesters

Biodigester volume (gallons)	Gas storage volume (cubic feet)	Rated daily gas production volume (cubic feet)
80,000	0	200
80,000	0	800
250,000	500	1,000
260,000	1,000	4,000
351,514	2,000	10,000
500,000	2,400	19,000
500,000	4,500	26,000
650,000	9,733	28,179
650,000	18,000	30,000
700,000	20,000	60,000
750,000	30,000	120,000
817,452	40,000	125,000
1,000,000	50,000	140,000
1,000,000	56,329	168,000
1,060,000	60,000	187,200
1,300,000	65,000	200,000
1,500,000	120,000	216,000
1,500,000	150,000	246,000
1,694,000	175,000	250,000
1,900,000		259,000
2,000,000		345,600
2,000,000		516,000
2,200,000		561,600
2,800,000		650,000
3,000,000		1,700,000
3,000,000		1,728,000
3,400,000		
3,500,000		
4,000,000		
4,400,000		
4,400,000		
4,400,000		
8,000,000		

BIOGAS FEEDSTOCK

The study shows that municipal wastewater is the largest source of feedstock in all biodigesters (38%). Manure from dairy cows is the second largest source of feed stock at 22%. Third largest, industrial high strength wastewater composed 18% of all sources of feedstock (Figure 10; Figure 11).

Depending on the scale of facilities, dairy based digesters receive manure from 250 to 5,500 dairy cows daily (a dairy cow produces about 14 gallons of manure daily). A few biodigesters use 1 to 2 tons of agricultural residues and some other reported to use up to 25 tons of food waste daily. Daily loading of municipal wastewater in their digesters varies from 1,500 to 40 million gallons. Many digesters reported using 2,000 to 3 million gallons of industrial high strength wastewater daily (Table 3).

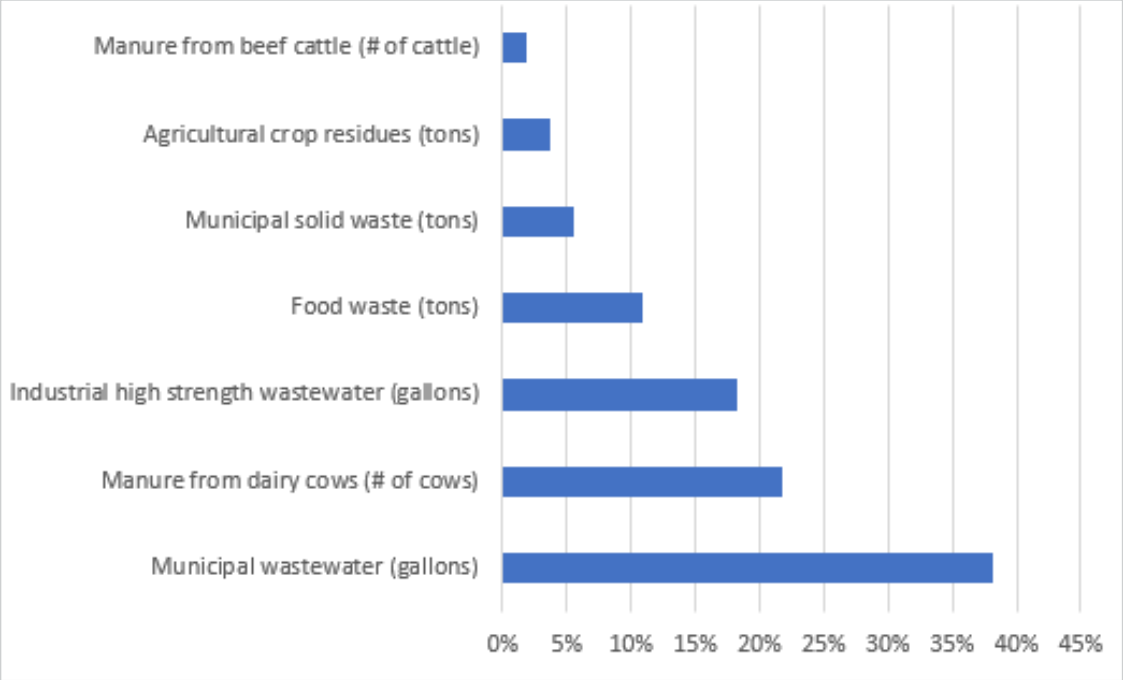


Figure 10: Primary source of feedstock by percent of total respondents

Farms

Agricultural wastes from crop cultivation and food production, livestock or farm manure.

Food Processing Facilities

Wastes from food processing at breweries, cheese factories, meat processors and related industries.

Wastewater Treatment Plant

Sewage sludge from municipal wastewater treatment and high strength wastewater from local industries.

Landfills

Edible and inedible food and other organic wastes from home, restaurants, caterers, supermarkets that often end up in landfills.

Figure 11: Waste sources for biodigestion (Kar, 2018)

Table 3: Daily loading of primary feedstock into digesters

Manure from dairy cows (# of cows)	Manure from beef cattle (# of cattle)	Agricultural crop residues (tons)	Food waste (tons)	Municipal solid waste (tons)	Municipal wastewater (gallons)	Industrial high strength wastewater (gallons)
1,100		2	25	600	20,000	4,000
2,800		1	15	10	45,000	2,894,400
4,600			2		12,000	2,500
5,500			1		144,000	2,000
5,000					6,000	30,000
2,250	400				100,000	90,000
5,350					20,000	100,000
3,200					10,000	85,000
2,500					1,500	200,000
250					20,000	65,000
2,400					40,000	
1,300					220,000	
					14,400	
					6,852	
					8,500	
					41,647	
					234,000	
					40,000,000	

Photo 4: Food waste-to-energy biodigester facility, Forest County Potawatomi Community Renewable Generation, LLC,

When asked about the use of supplemental feedstock in their biodigesters, more than 40% of respondents indicated that they did not use any. About 20% reported using industrial wastewater as supplemental feedstock in municipal wastewater based biodigester facilities. Other supplemental feedstocks that are used include food waste, grease, and agricultural residues (Figure 12).

Out of the 37 facilities that receive supplemental feedstock, the largest portion (32%) receive supplemental feedstock from food processing industries. About 16% of them reported receiving supplemental feedstock from restaurants and 14% receive supplemental feedstock from breweries. About 8% receive supplemental feedstock from supermarkets or grocery stores. A total of 19% of

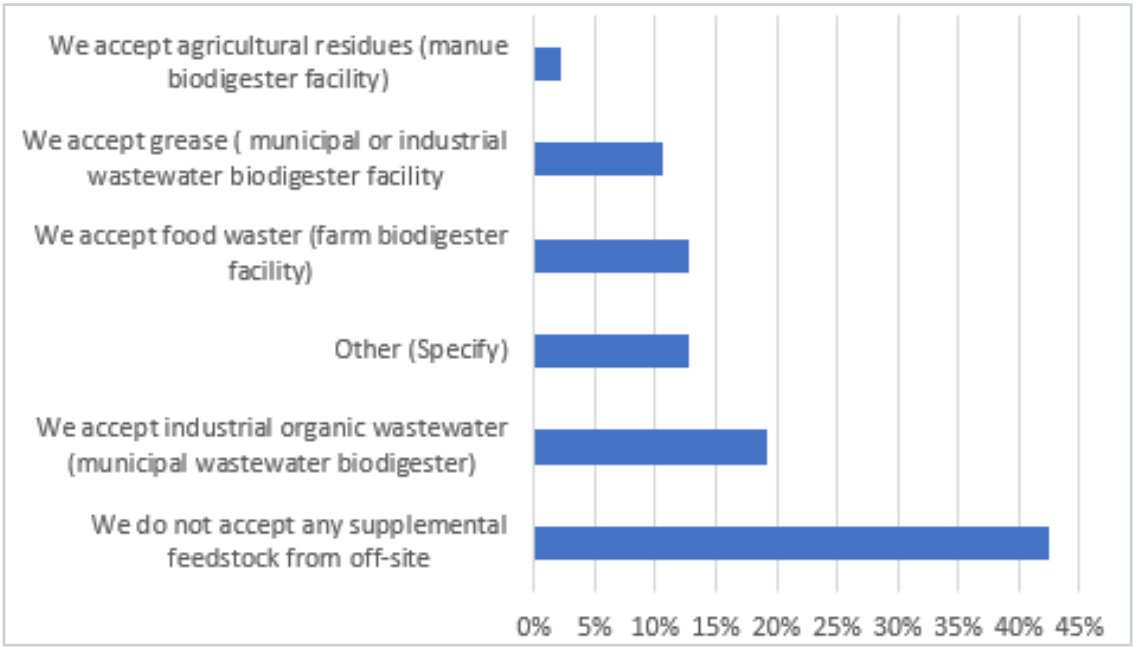


Figure 12: Acceptance of supplemental feedstock

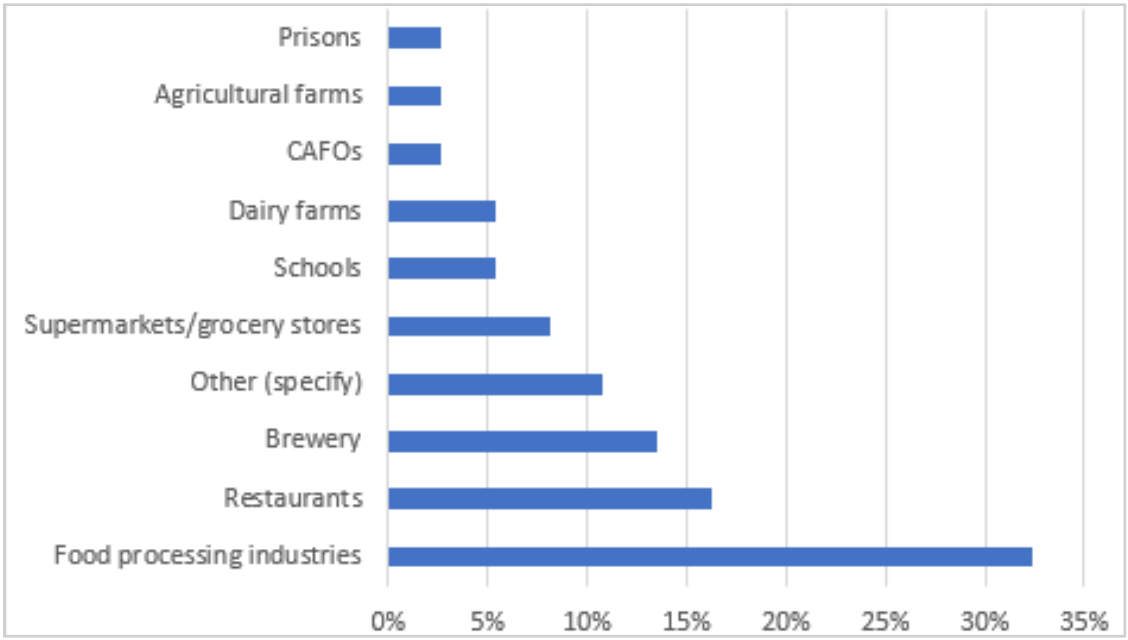


Figure 13: Sources of supplemental feedstock accepted

those facilities receive supplemental feedstock from schools, dairy farms, CAFOs, agricultural farms, and prisons and 11% receive supplemental feedstock from other places (Figure 13).

Only one biodigester facility has all feedstock available on-site out of 23 respondents. About one-quarter of the primary/supplemental feedstock travels 21-50 miles to get to a biodigester facility, followed by 22% that travels 6-10 miles to a facility. Only 2 (9%) respondents reported that primary/ supplemental feedstock travels more than 50 miles to their facility (Figure 14; Map 3).

Facilities face many challenges in feedstock acquisition. Top ones include storage (18%), inconsistent timing and frequency of feedstock deliveries (13%), and contaminants in the feedstock (13%) as well as other quality-related concerns. The biggest challenges faced by facilities in feedstock acquisition include: storage (24%), cost of transportation (11%), and inconsistent timing and frequency of feedstock deliveries (11%) (Figure 15).

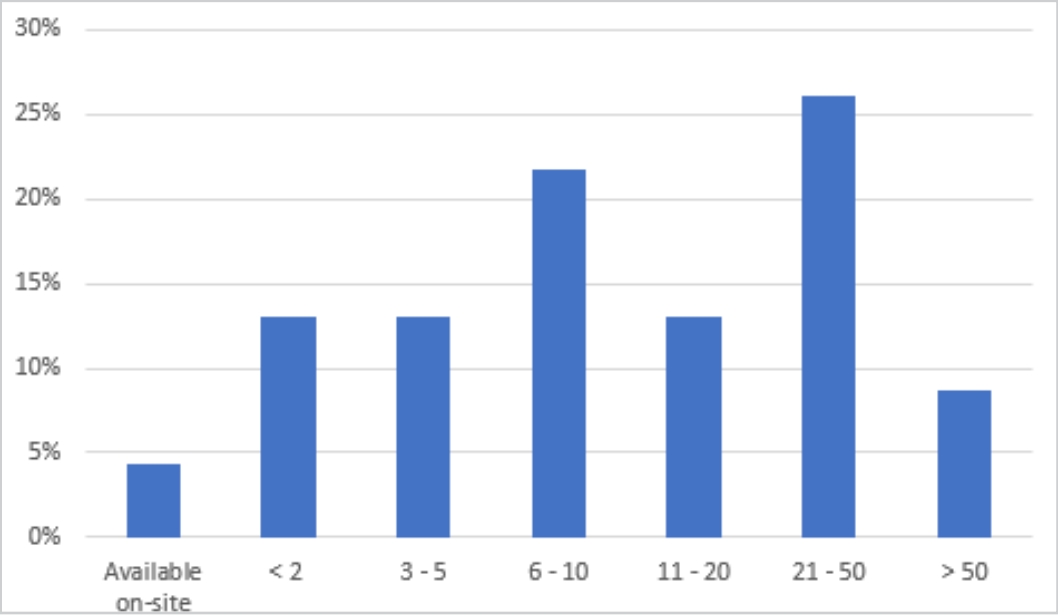


Figure 14: Distance traveled for feedstock collection

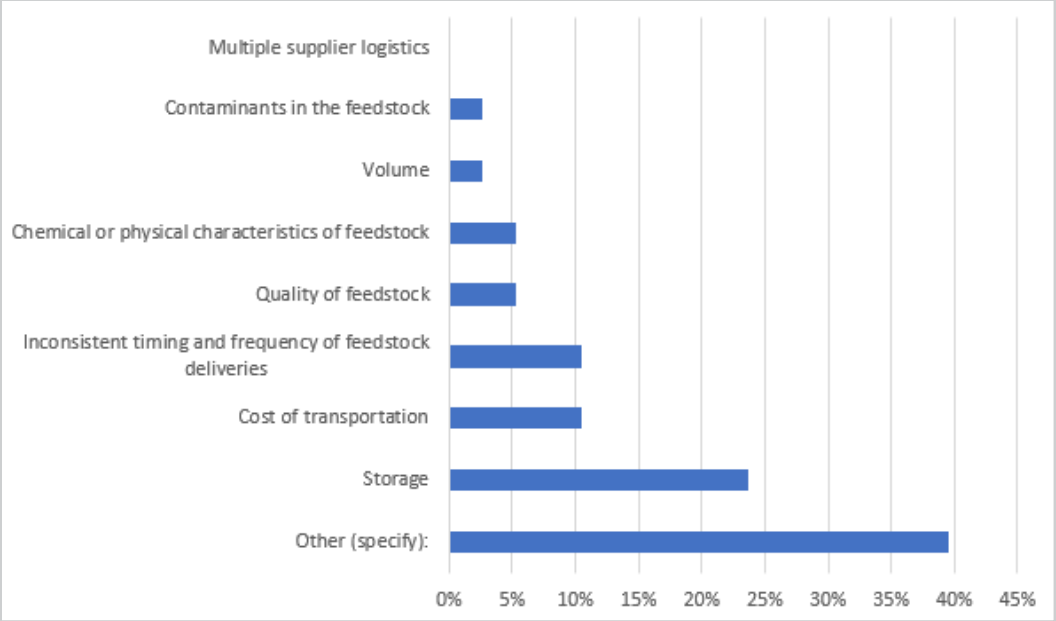
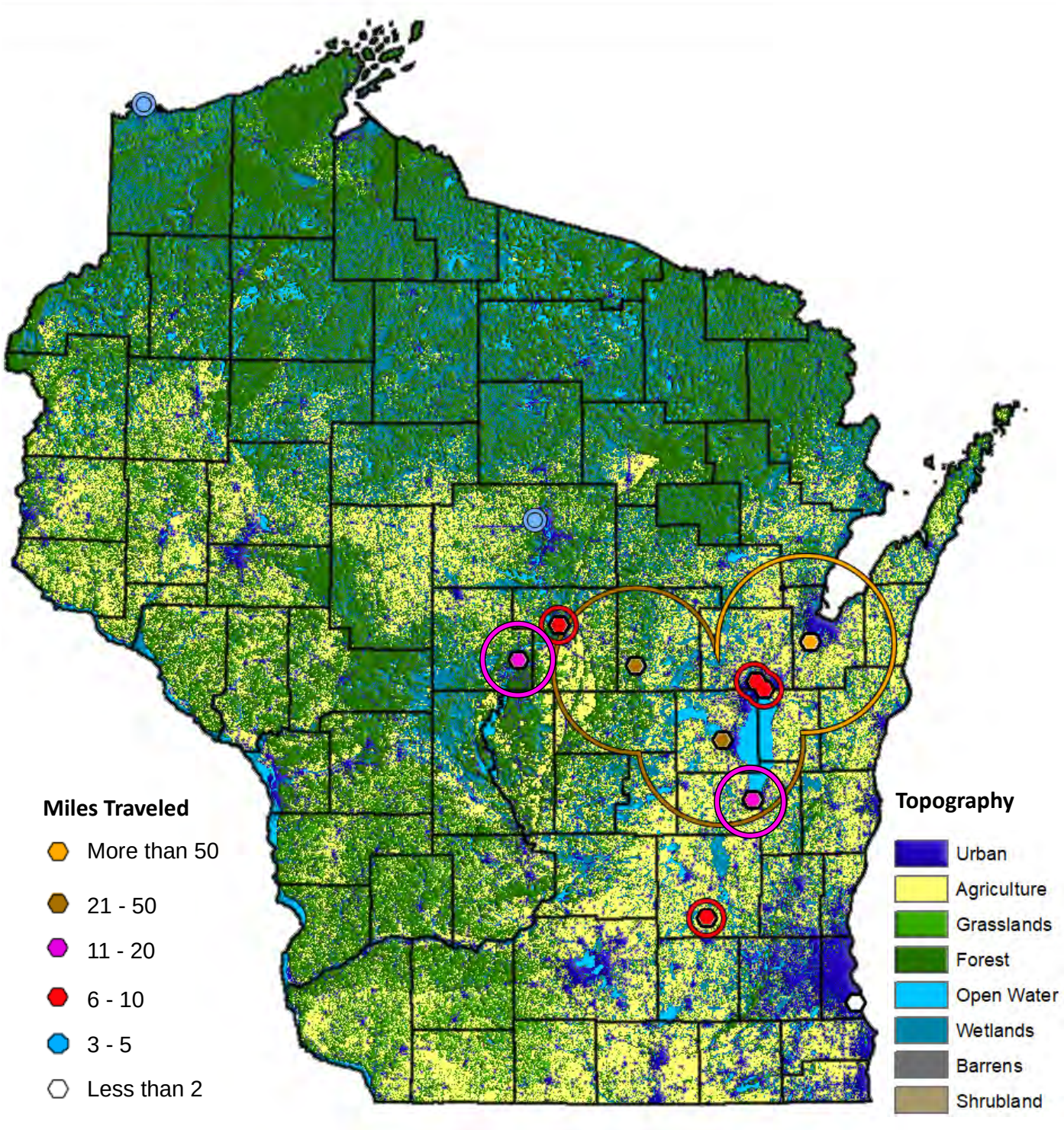


Figure 15: Challenges in feedstock acquisition



Map 3: Demonstration of distance traveled for feedstock collection

Operations and Maintenance

Most of the biogas facilities have 1 to 5 staff for operations and maintenance. Out of 39 respondents, one-third reported having only 1 staff member to operate or monitor the anaerobic digestion system and process, and about 40% said they have 2 to 5 employees for this purpose. About 29% of the respondents mentioned having 6 to 25 employees for this purpose (Figure 16).

Nearly half of the biogas facilities reported that their annual cost of operation and maintenance is below $100,000. The rest of the facilities reported the cost being above $100,000 and a significant portion of them mentioned about spending more than $150,000 (Figure 17).

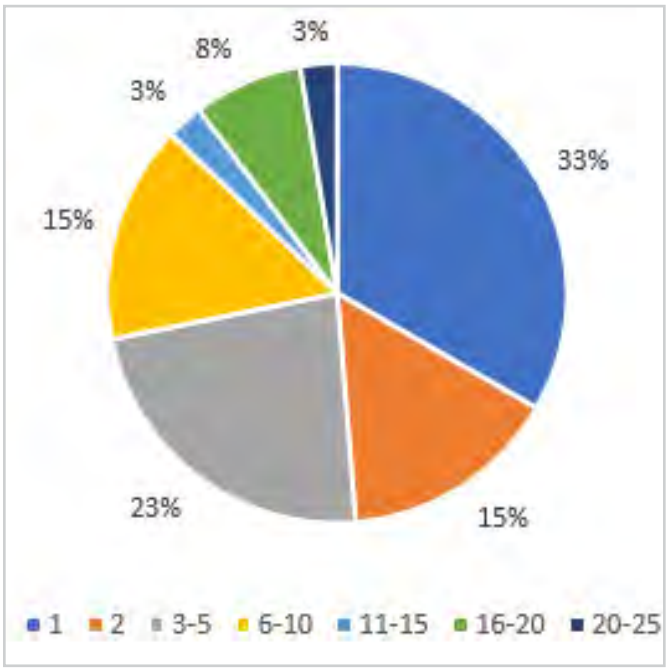


Figure 16: Number of employees for operations and maintenance

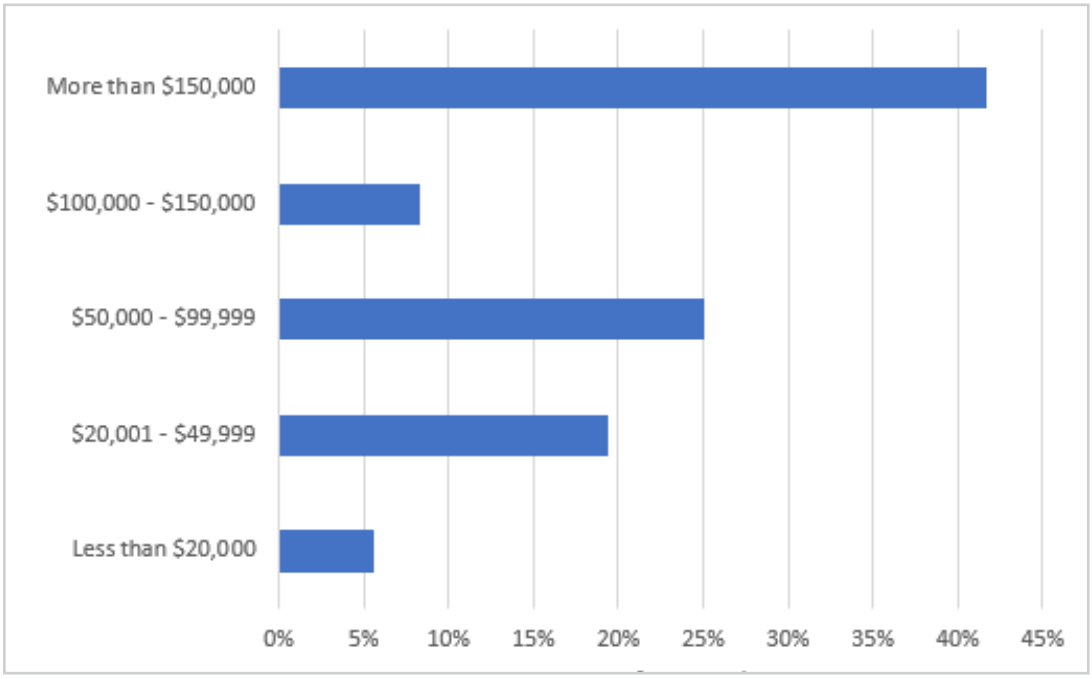


Figure 17: Annual cost of biogas facility operations and maintenance

Taking cost effective measures is critical for running biodigesters. About 72% of respondents reported taking measures to make the biogas facility operations or maintenance more cost-effective. Many of those reported measures include (Figure 18):

- Producing electricity and heat from the turbines that reheat the digesters.
- Making compressed natural gas for vehicles.
- Pre-heating feedstock, cleaning heat exchangers, screening feedstock, taking out pumps & using gravity, optimized chemistry in facility, utilizing biogas within facility for energy production, discharge to local municipality and acceptance of reclaimed water from municipality.
- Installing Variable Frequency Drives (VFD's).
- Keeping manure flow as simple as possible.
- Performing nearly all work in house.
- Switching to more efficient pumps with higher quality materials that last longer.
- Performing maintenance of digester gas burning heat exchanger units and undertaking measures to improve efficiency of the digested sludge dewatering process.
- Performing regular maintenance of biogas boilers, biogas scrubbers.
- Sharing spare parts with other sites and changing H2S media to a more efficient less costly type.

Figure 18: Measures taken to improve cost-effectiveness of operations and maintenance

- Minimizing loading as much as possible.
- Ensuring the highest percent solids entering the digestion process.
- Having measures on chemical management, service/ maintenance management.
- Managing microbes.
- Enhancing energy efficiency of blowers, compressors and chiller units.
- Ensuring mixer optimization, biogas utilization optimization and heat balance management.
- Managing operations and maintenance by outside companies.
- Electrical efficiencies such as high efficiency motors and VFD's are incorporated if applicable and as part of refurbishments.
- Modifying the heat exchanger to be more efficient and by upgrading mixing system.
- Routine maintenance - pump upgrades where needed to maintain proper insulation.
- Maximizing the high strength waste feed-stocks.
- Proactive maintenance plan to ensure more uptime of the equipment
- Changing tipping fees to help with revenue.
- Increasing heat exchanger burner efficiency.

Having pipeline infrastructure developed to connect and inject the refined biogas to intra- or inter-state natural gas pipelines can create a new opportunity for the biogas facilities. However, only 5% of respondents—2 facilities out of 37—reported having a pipeline to inject biogas to the pipelines. Some of the facilities with pipeline infrastructure indicated they have equipment constantly monitoring gas quality that automatically shuts off if unspecified gas is detected. They also take precautions to measure BTU (a measure of heat) values before injecting into a distribution pipeline.

Photo 5: Pipeline injection of biogas from a Dane County Landfill, Dane County Public Works, Madison, WI

Reported challenges to daily biodigester operation include: cleaning up biogas for onsite use (14.16% of facilities), generator malfunction/maintenance (13.27%), foaming (12.39%), variation in quality or quantity of biogas production and daily overhead costs for operation (9.73% each) (Figure 19).

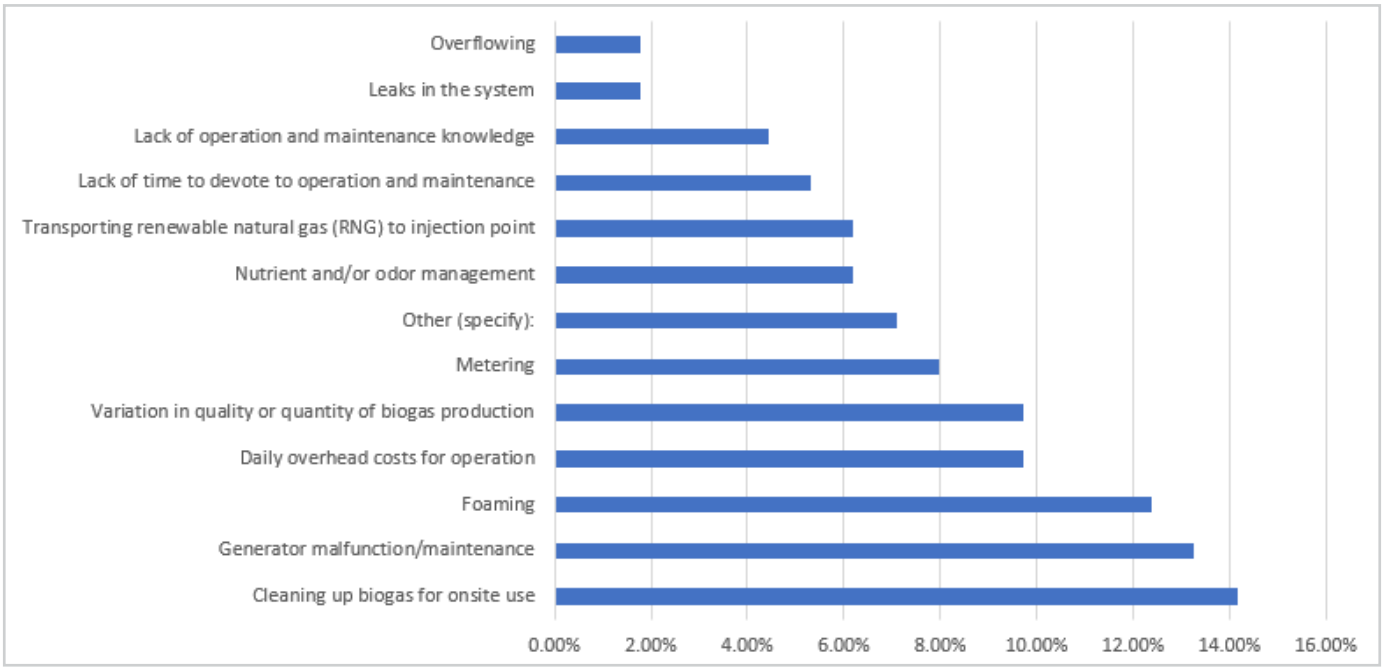
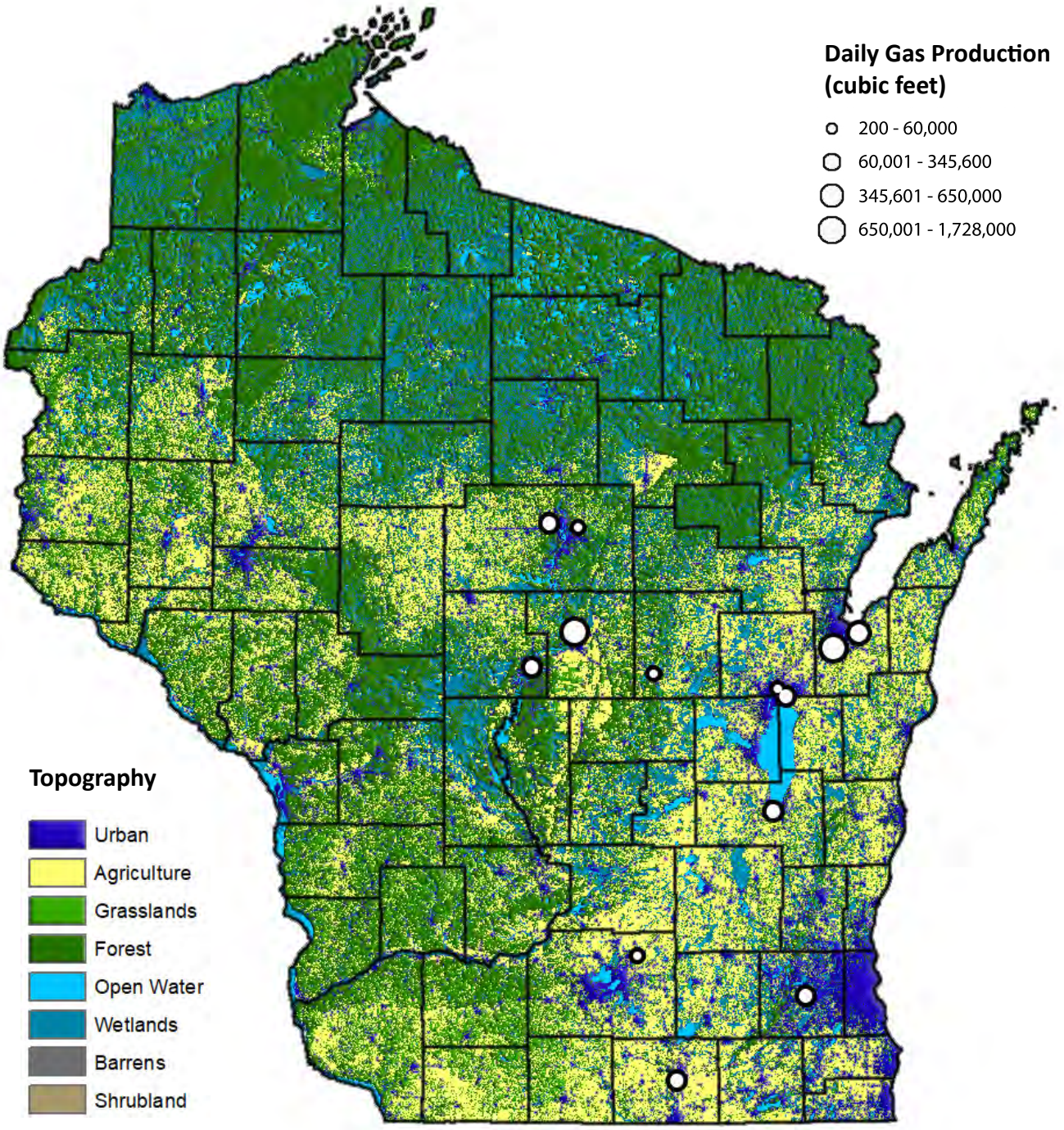


Figure 19: Challenges to daily biodigester operations

Photo 6: Feedstock separator at a dairy digester, Clean Fuel Partner, LLC

Photo 7: Dairy Biogas Anaerobic Digester Facility, Clean Fuel Partners, LLC, Dane, WI



Map 4: Average daily production of biogas in various facilities

Biogas Production and End Use

Findings show that one quarter of facilities produce 25,000 actual cubic feet of biogas on average per day, while another quarter produces 100,001-250,000 actual cubic feet per day. Nearly 15% of facilities produce more than 500,000 actual cubic feet of biogas per day (Figure 20).

Nearly 23% of facilities use their biogas production to provide heat for the biodigester process and another 23% facilities use the biogas for their facility heating. About 14% of facilities use their biogas to produce electricity while 8% use it for cogeneration of electricity and heat. Only a small percentage of facilities reported using the biogas as compressed natural gas or inject to natural gas pipelines. About 21% of facilities flare the biogas (Figure 21).

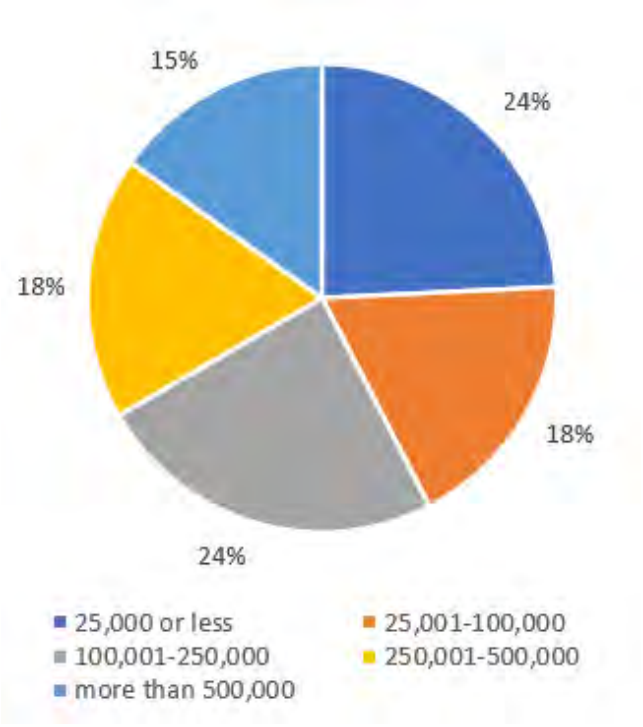


Figure 20: Daily biogas production in cubic feet

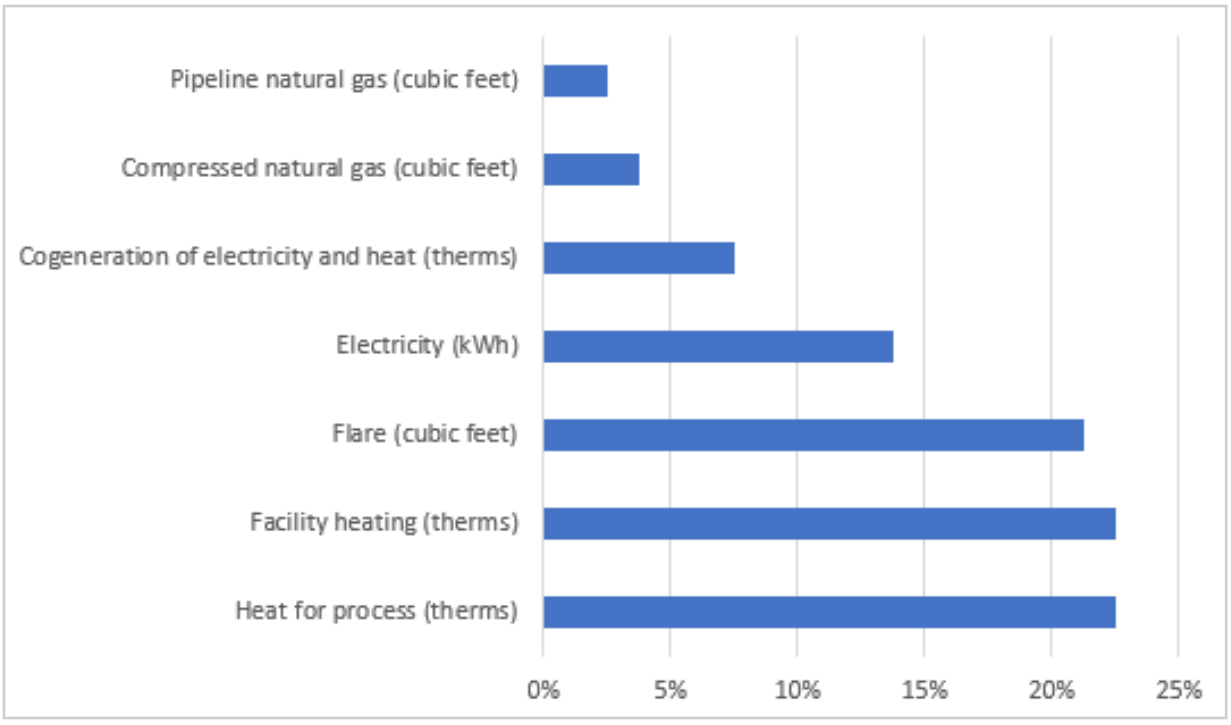


Figure 21: End-use of biogas produced at facilities (cubic feet)

About one quarter of facilities generate bedding for livestock and fertilizer as co-products of biogas production. Nearly 16% generate waste heat recovery as a coproduct and 12% generate flush water. About 12% of facilities generate no co-products. A few facilities reported producing 20 to 40,000 cubic yards of bedding for livestock per year. Some facilities produce 2,000 to 30,000 cubic yards of fertilizers and about 1 to 2 million gallons of liquid concentrated fertilizer annually (Figure 22).

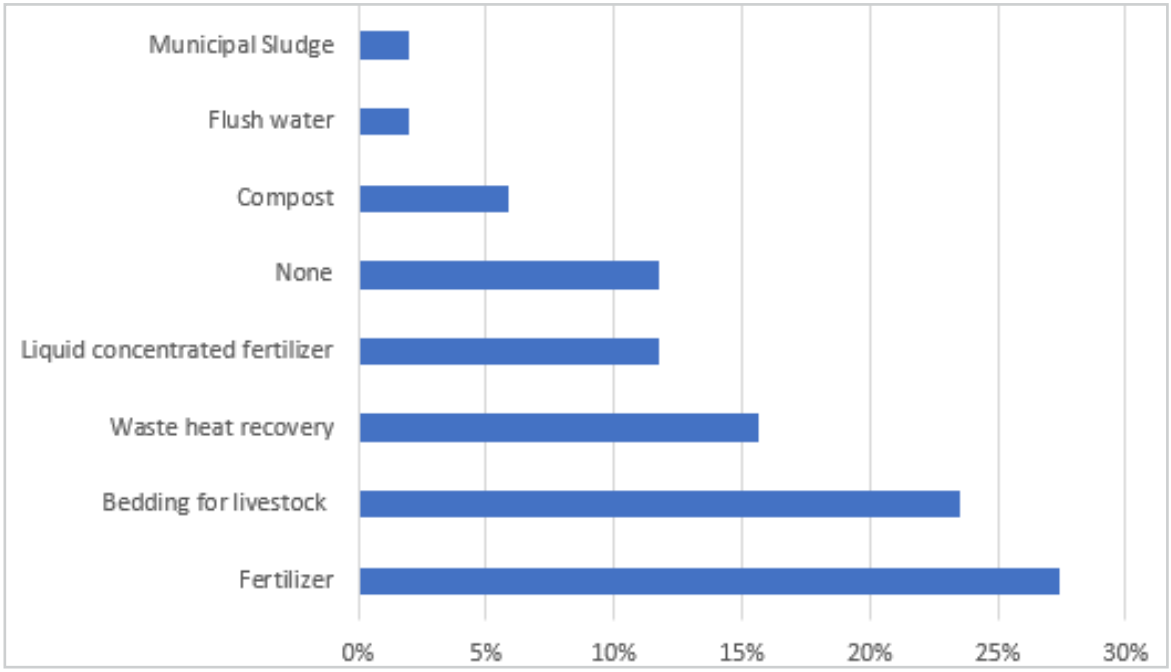


Figure 22: Co-products generated by the biogas facilities

Photo 8: Clean bedding by-product, Holsom Dairies, Irish and Elm, Hilbert, Wisconsin

Study shows that only 21% of the facilities sell biogas. They sell biogas mostly through an intermediary and some of them sell on their own to the buyer directly.

About two-third of the biogas facilities reported having a current nutrient management plan that is vital for their operations (Figure 23).

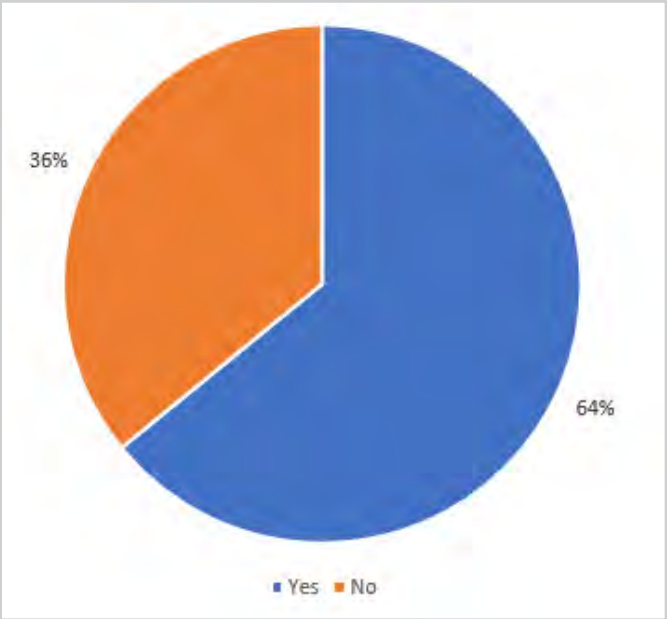


Figure 23: Facilities with nutrient management plan

Challenges and Policies

Reported challenges faced during biogas digester adoption include: permitting (16% of facilities), waste contracts (13%), nutrient management concerns or regulation (12%), generator commissioning (10%), and the grant writing process (10%). Other challenges include funding of the project, biogas cleaning cost, maintenance of engines, and finding practical use of the biogas produced (Figure 24).

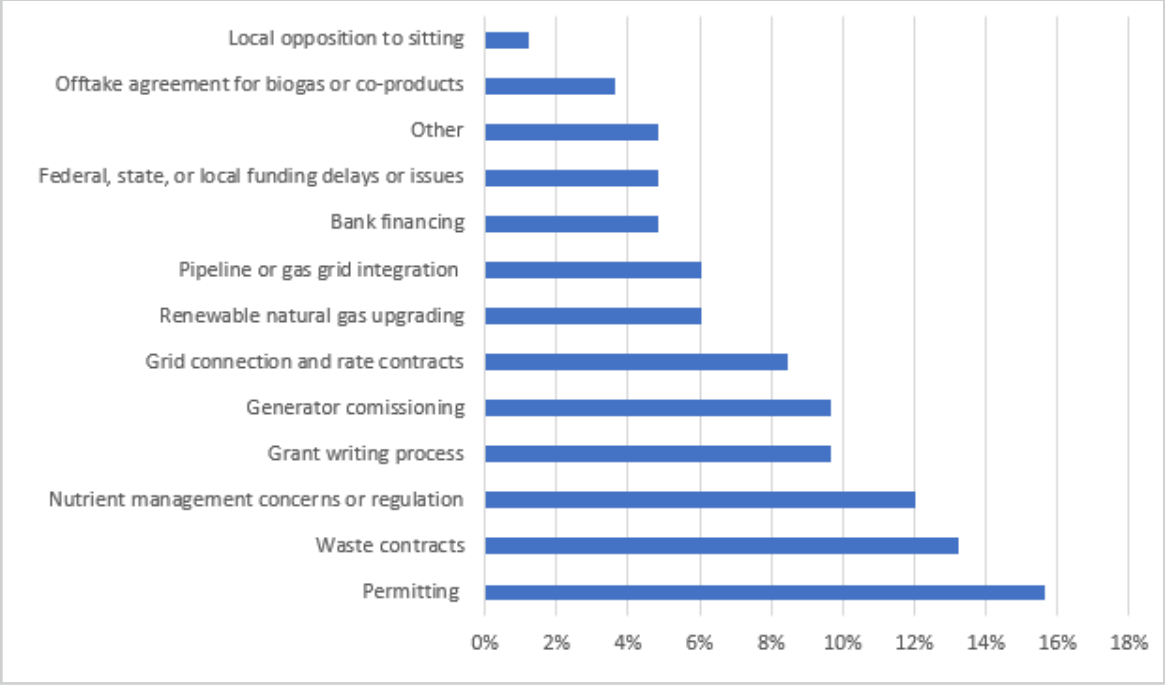


Figure 24: Challenges in facility biodigester adoption

Reported resources or assistance that were helpful in planning for the financing, construction, and implementation phases of facilities' biodigester system include: assistance from the biodigester vendor/utility company/biogas marketer (20%), funding assistance from federal/state sources (19%), outside assistance (consultants) with grant writing and funding (14%), and assistance from state and local officials (13%) (Figure 25).

The policies or practices that would have been the most helpful in financing, construction, and implementation of the facilities' biodigesters include more specific federal incentives or grant opportunities for biodigesters (21% of facilities), more state energy incentives or funding (18%), higher prices or assistance in renewable energy credits (11%), and less stringent permitting requirements (10%) (Figure 26).

Figure 25: Resources utilized for current biodigester implementation

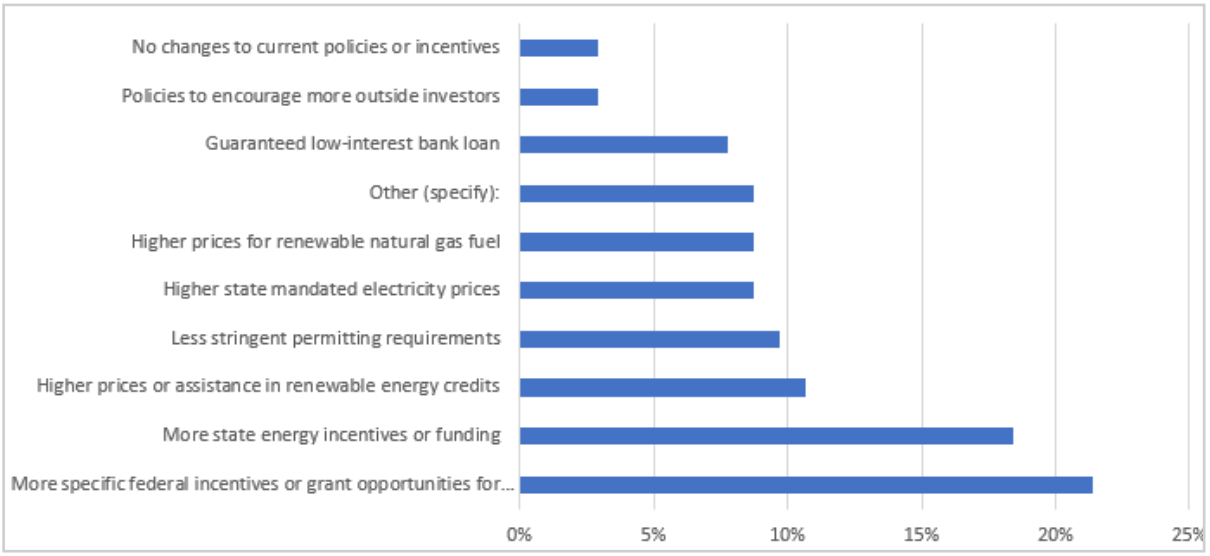


Figure 26: Policies and practices that would have helpful

Only 21% of facilities have a Power Purchase Agreement (PPA) with a local utility, while the remainder do not. Some of the utilities include Xcel Energy, WPS, WE Energies, Alliant Energy, and Water Works and Lighting Commission. Many of these PPAs are set to expire in next couple of years (by 2023).

A majority of the respondents who sell electricity receive $0.09/kWh or less electricity rate, however; many of them prefer having a higher rate of electricity that could help them reach the break-even or start making profit out of biogas operations (Table 4; Figure 27).

Table 4: Electricity rate received by biogas facilities

Response	Count	Percent
Only flare or boiler	16	55%
$0.07 - $0.09 / kWh	4	14%
Only use on-farm	2	7%
Renewable natural gas only	2	7%
$0.10 - $0.12 / kWh	2	7%
$0.01 - $0.03 / kWh	1	3%
$0.04 - $0.06 / kWh	1	3%
Non-disclosure agreement with the utility	1	3%
Total	**29**	

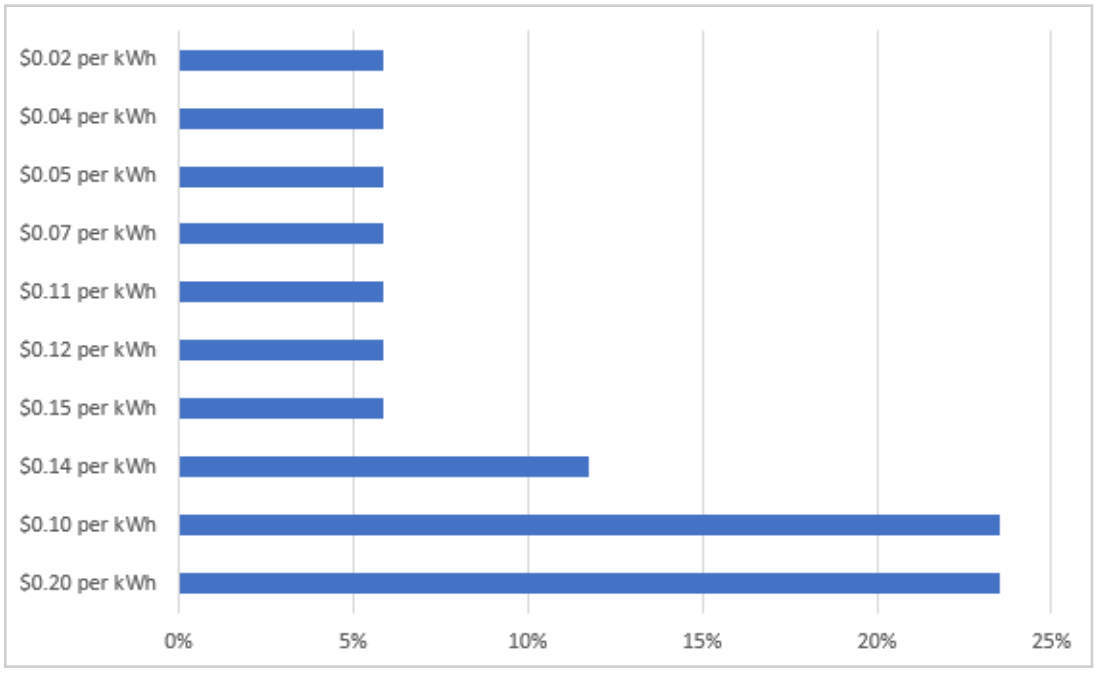


Figure 27: Electricity rate required to break-even or profit

When asked, nearly 59% respondents neither agreed or disagreed with the statement “We should have a better net metering law to support biodigester operation in Wisconsin” while one-third of them agreed. About 45% of the respondents agreed that there should be a state-level policy to mandate electricity price for biodigesters, while 15% of respondents disagreed. Over half of the respondents also agreed on having more supportive policies that mandate food waste diversion from landfills, while 13% disagreed. Similarly, over half of the respondents agreed that there should have a better U.S. renewable fuel standard policy for assisting in biogas

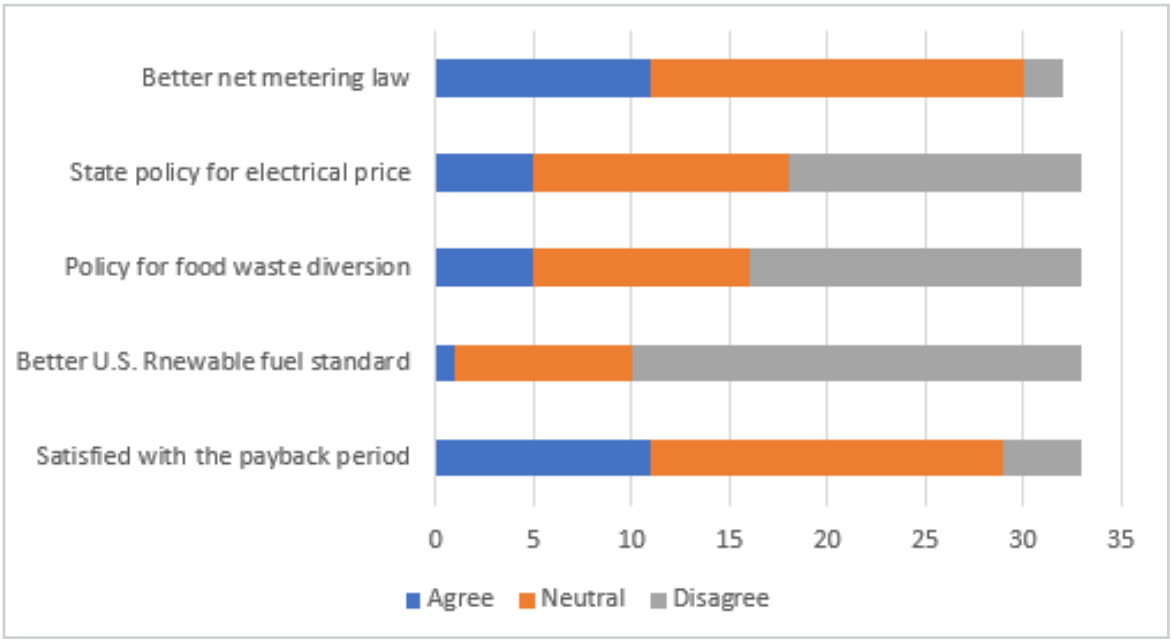


Figure 28: Respondents’ agreement or disagreement with biogas related policy issues

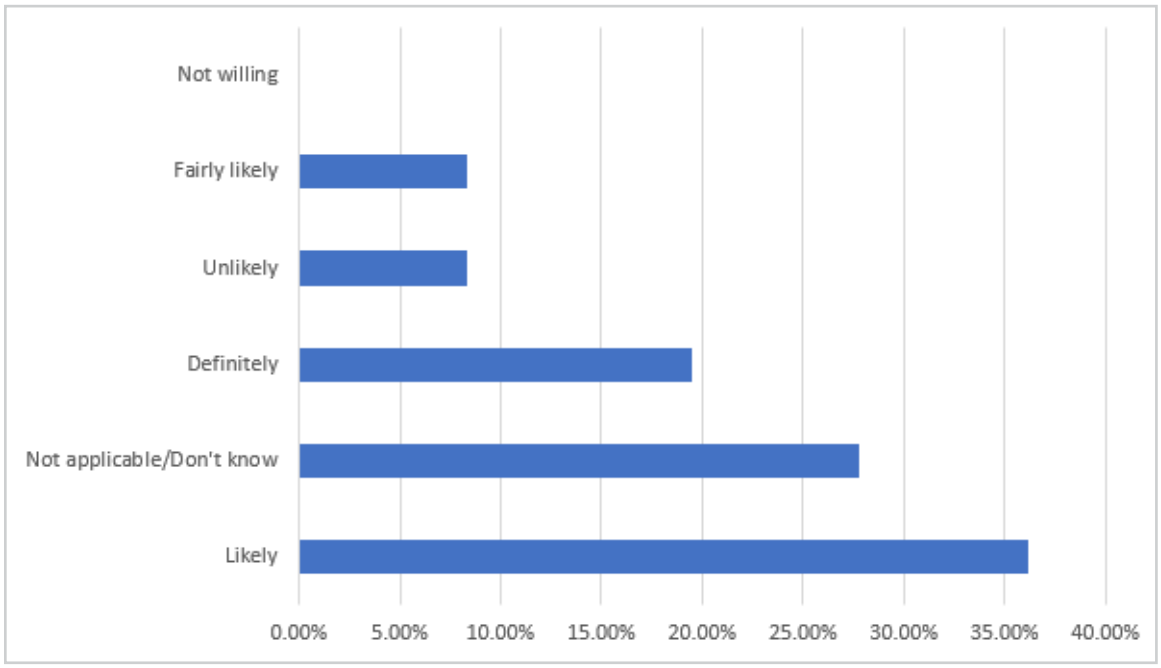


Figure 29: Likelihood of investing in another digester

implementation, while 13% disagreed. A large portion of the respondents were neither satisfied or unsatisfied with the payback period for their biodigester system (Figure 28).

Nearly 36.11% of facilities stated that they would be likely to invest in another digestion system in the future, while 19.44% stated that they would definitely invest in another digestion system. About 28% stated that this question was not applicable/ they didn't know, and no respondent stated that they would be unwilling to invest in another digestion system (Figure 29).

The changes facilities would make to their digestion system(s) if they had the resources include: better handling/mixing/separator/H2S scrubbing system and better heating system (16% each), better ability to manage nutrients in digestate (14%), as well as having different substrates to put in the biodigester and adding renewable natural gas capability (10% each). Other potential changes include pre-treatment of substrates prior to digestion, changing electric generator capacity, having different power purchase agreement and allocating more time to daily operation maintenance. (Figure 30)

Facilities reported that the most important changes they would make to their digestion system(s) if they had the resources are better handling/mixing/ separator/H2S scrubbing system (18% of facilities agreed), better heating system, pre-treatment of substrates prior to digestion, and changing electric generator capacity (12% each) .

Most of the biodigester facilities have a membership or work with a relevant supportive organization. About 29% of facilities work with the Wisconsin Department of Natural Resources (WDNR) and 26% work with Focus on Energy. Other organizations include Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), United States Department of Agriculture

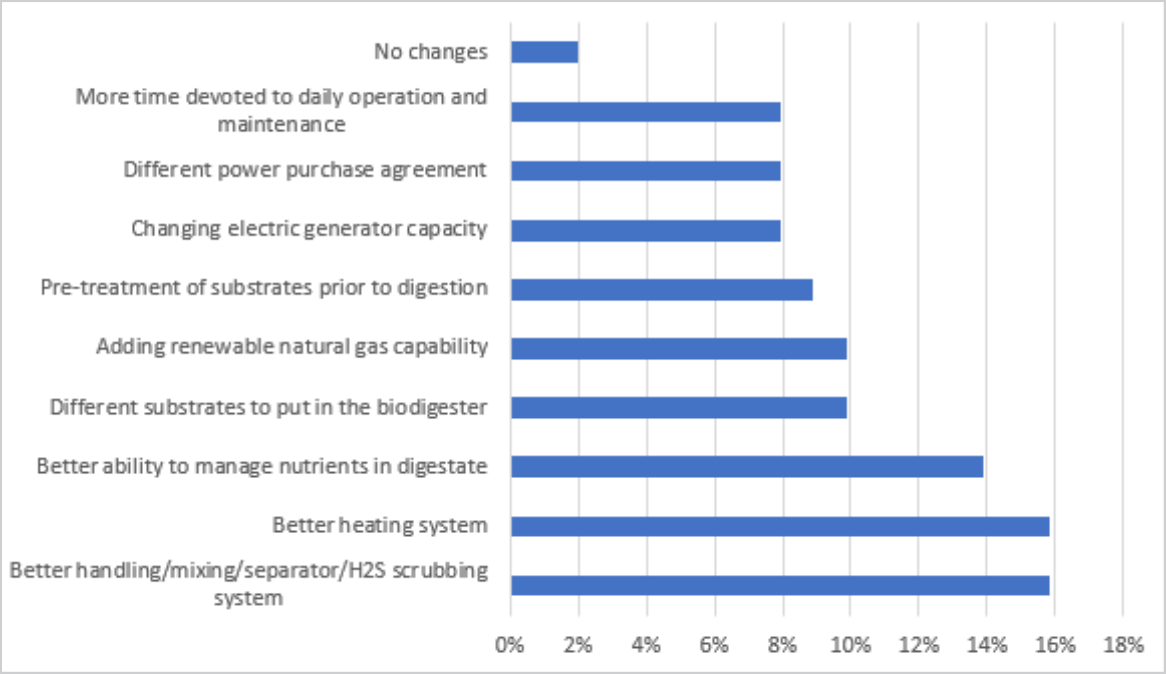


Figure 30: Change facilities would make if resources were available

(USDA), Natural Resources Conservation Service (NRCS), American Biogas Council, UW-Madison Extension, Wisconsin Biogas Council, Green Tier Legacy Communities (WDNR), and AgSTAR by the Environmental Protection Agency (EPA) (Figure 31).

When asked respondents if they would be interested in pursuing or receiving assistance in their facility's operations from any organizations, almost 40% respondents showed no interest in pursuing help. However, some of the facilities expressed their interests in pursuing or receiving

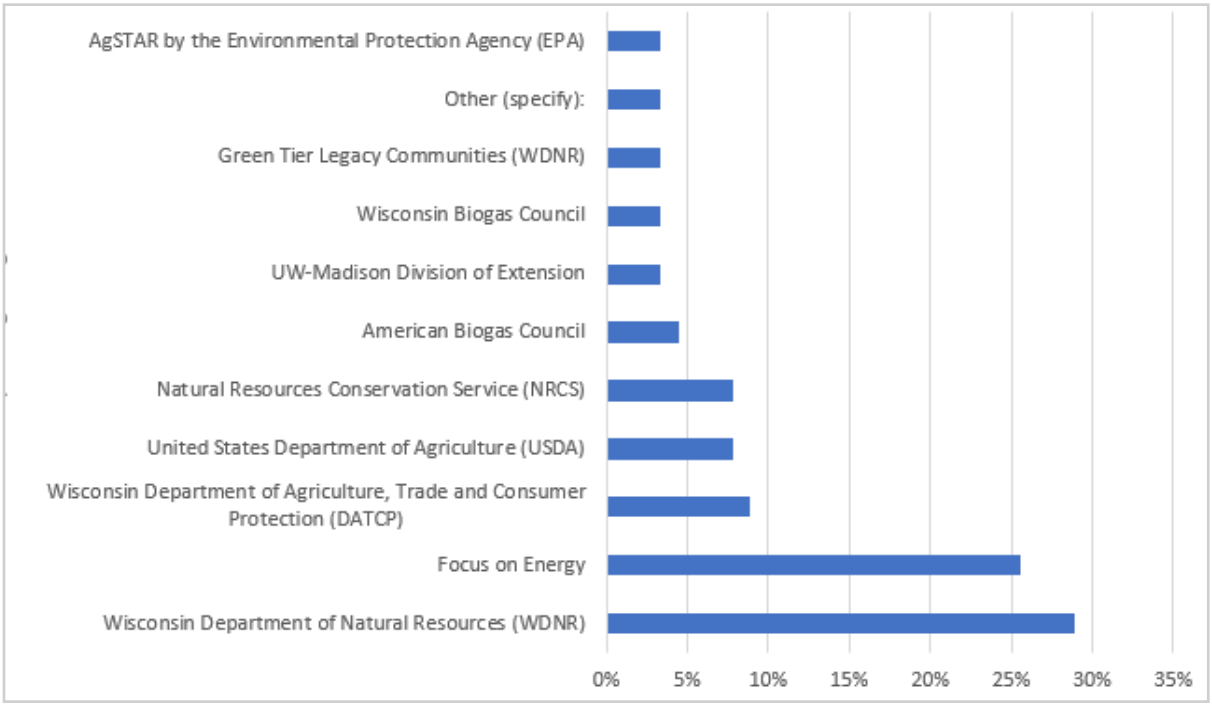


Figure 31: Memberships in related biogas organizations

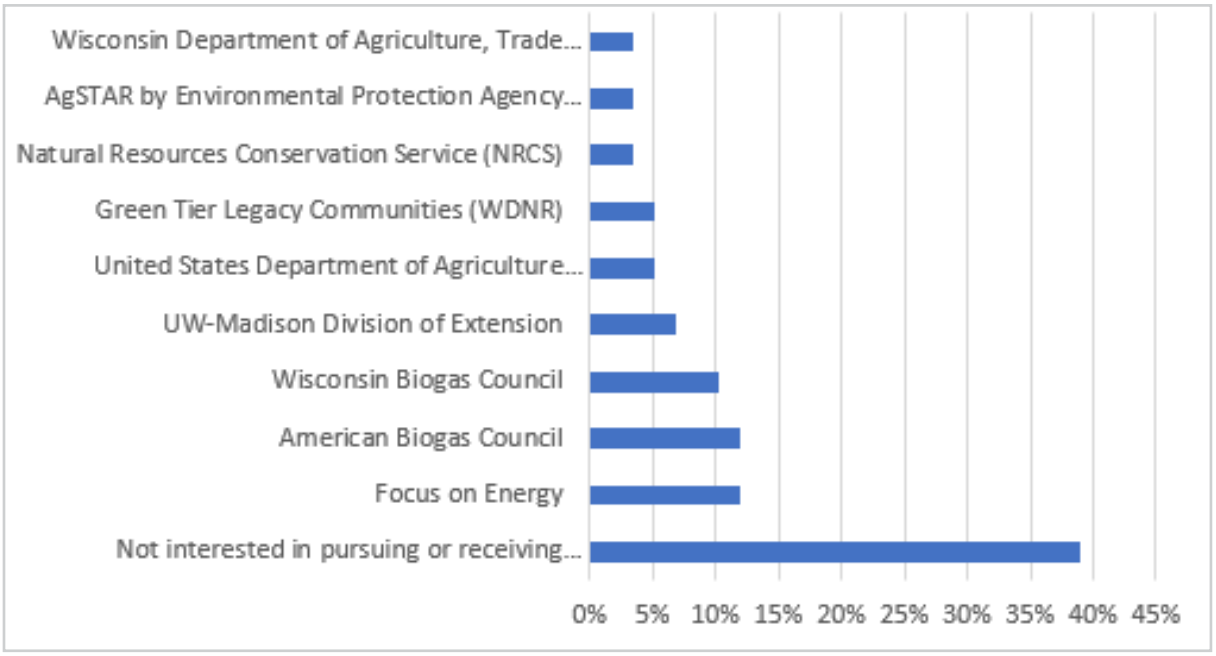


Figure 32: Respondents' interest in receiving assistance from various organizations

assistance from several organizations that include Wisconsin Department of Natural Resources, Focus on Energy, American Biogas Council, Wisconsin Biogas Council, and the UW-Madison Extension (Figure 32).

When asked about types of assistance they need, most of the respondents are interested in financial assistance. Other types of assistance include: technical help, training and supportive changes in state policies (Figure 33).

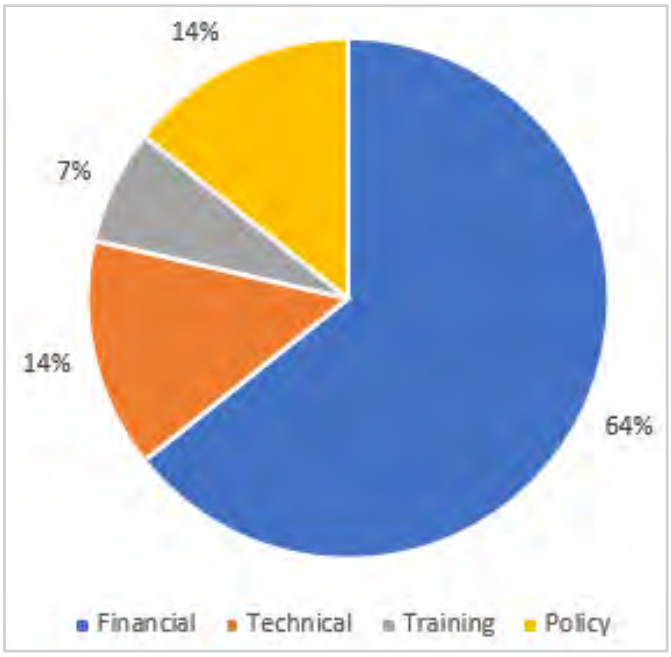


Figure 33: Types of assistance desired

Facilities with Inactive Biodigesters

Out of the 30 facilities who said they currently do not have an active biodigester, 23% have had an operating anaerobic biodigester within the last 5 years. Primary reasons that facilities chose to decommission their biodigester include: the biodigester not making economic sense anymore (25%), not having time or personnel to monitor or manage the digester (18%), not having enough technical support (7%), and impacting other farm activities (2%). Other reasons include: having small systems/producers and not producing enough waste, challenges in transporting waster to other established operating biodigesters, WWTF upgraded to an aerobic process, and not knowing much about technical aspects, regulations and costs. Many mentioned that they are a landfill, or have an aerobic process, or their facility is too small (Figure 34).

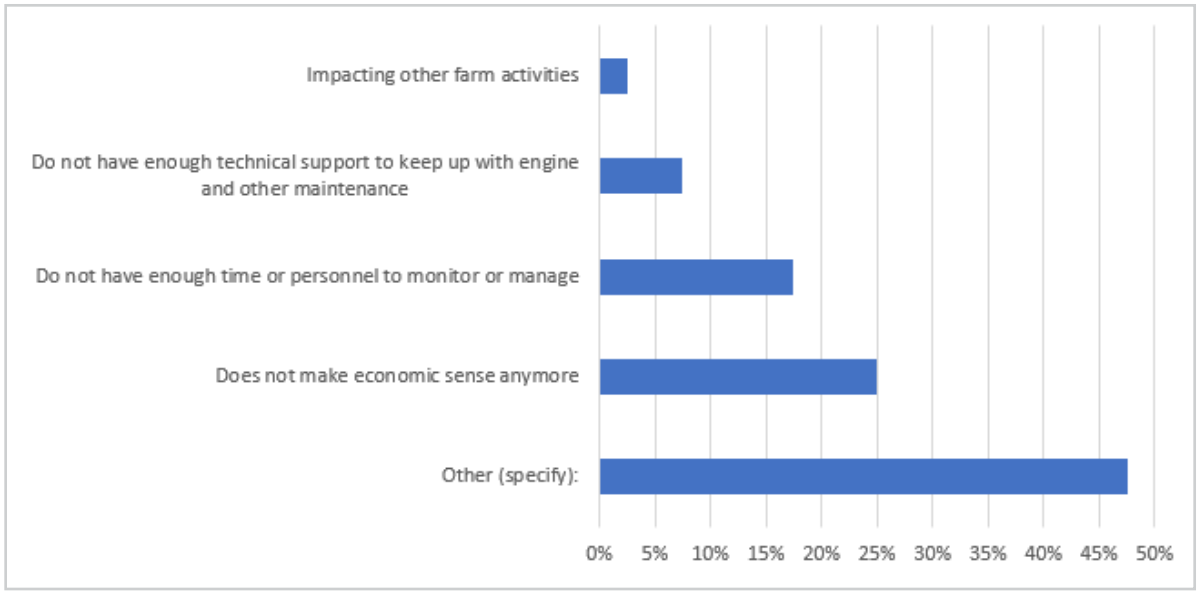


Figure 34: Reasons for inactive biodigesters

According to a respondent, “For a waste stream to be dedicated to a digester, that waste stream would have to be either source separated or sorted at a mixed waste processing facility. Given the infrastructure for collecting source separated organics/wasted food or for mixed waste processing sorting is basically non-existent, then the most efficient way to manage the waste stream is to landfill it. Until a sustainable infrastructure for collection and or processing is built, then organics/ wasted food will not go to digestion. As well, small digesters will have a hard time paying the $2-$4 million for pipeline access, if their goal is to deliver RNG to the pipeline. Many saying that they are a landfill, or have an aerobic process, or their facility is too small.”

Top challenges of having a biodigester include being too small operator to make it feasible, low electricity rate contract, not being aware of the relevant policies and regulations, bank financing, time and help needed to write grants for funding, and permitting concerns.

The most useful policies or practices that would help facilities without a biodigester adopt one include: additional federal, state, or local grant opportunities for capital costs (26.92%), and more Environmental Quality Incentives Program (EQIP) funding (15.38%), and policies encouraging more outside investors and mandating higher electricity rate for biodigester facilities (for selling to utilities) (Figure 35).

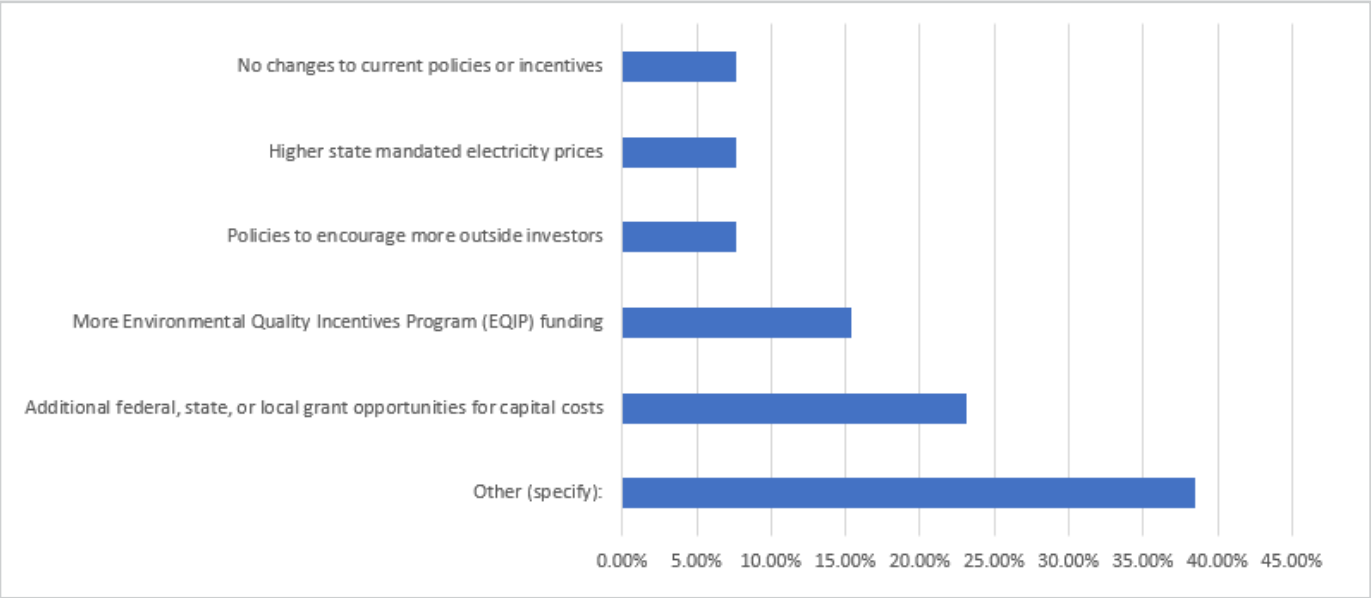


Figure 35: Policies and practices to assist in biodigester adoption

Key Observations and Recommendations

The survey indicates that a majority of the biodigesters in Wisconsin are installed in municipal wastewater treatment facilities (WWTFs) followed by dairy and agriculture sector-based biodigesters, food processing and industrial waste based biodigesters, and landfills biogas systems. Most of these biodigester facilities have been built within last 50 years (1970 to 2020) with a large number of biodigester additions in last decade (2010-2020). Not all installed biodigesters are currently operational. Odor control, enhancing renewable energy production and facility income are the primary motivators for biodigester adoption. Biodigesters are playing an important role in the facility operations and income. Biodigesters cost about $3 millions or more to install, however; small-scale biodigesters can be installed with less than $100,000. Most of the biodigesters in Wisconsin are built by biodigester contractors; although most contracts do not have monitoring and maintenance included. A large number of biodigester facilities were built without any grant support. Among the facilities which received grants, most received about 10 to 30% grant funding to offset their installation costs. Most of the biodigester facilities have volume capacity of 2 million gallons to handle the slurry. Average biodigesters in Wisconsin have 42,000 cubic feet of gas storage capacity and daily rated gas production volume capacity of 300,000 cubic feet.

Municipal wastewater is currently used as the largest source of biogas feedstock in current biodigester facilities. Manure from dairy being the 2nd largest source of biodigester feedstock. Daily loading of feedstocks varies significantly based on the types of feedstock and biodigesters. A large number of biodigester facilities do not use any supplemental feedstocks. Biodigesters in many WWTFs use industrial high strength water as supplemental feedstock. Other biodigester facilities that use supplemental feedstocks, receive those from food processing industries, restaurants, breweries, and several other sources. Most of the feedstock tend to come from a 20 miles radius of the biodigester facilities although some facilities collect from 50 miles or more. Some challenges for feedstock acquisition include storage, inconsistent timing, frequency of feedstock supply, and contaminants in feedstock.

Most biodigesters in Wisconsin have 1 to 5 staff for their operation and maintenance. The annual cost for biodigester operations and maintenance could vary—half of the respondents reporting it to be below $100,000 while the others mentioned about a higher range of $150,000 or higher. Most of the biodigesters tend to take cost effective measures in their operations. Some of the efficient measures include maintenance of the heat pump and exchanger, using heat for process, managing the loading of feedstocks, managing chemical process, and microbes. Very few biodigester facilities have infrastructure to inject refined biogas into the natural gas pipeline. Injection into the pipeline has significantly higher financial potential.

The top challenges to operations and maintenance include:

- cleaning biogas for onsite use
- generator malfunction
- foaming
- maintaining quality and quantity of biogas
- overall cost of operations.

Depending on the size and capacity of the biodigesters, the daily production rate of biogas varies from 25,000 cubic feet to more than 500,000 cubic feet. A large number of biodigester facilities use the biogas they produce as process heat and for their facility heating. Many biodigester facilities also produce electricity using the biogas while a small percentage of biodigesters have cogeneration facility to produce heat and electricity together. Most of the biodigester facilities generate coproducts such as fertilizers, composts, bedding for livestock, and waste heat recovery for heating space. Most of the biogas facilities do not sell their biogas while a small percentage of them sell it either directly or through an intermediary. To comply with the regulations and environmental issues, most of the biodigester facilities have a current nutrient management plan.

Biodigesters in Wisconsin currently face many challenges. Some of the major challenges in adopting a biodigester include: permitting, waste contracts, nutrient management concerns and regulations, generator commissioning, and grant writing. Assistance that might be helpful include support from contractors, utilities and vendors, funding support from state and federal sources, help with grant writing process and more support from state and local officials. Several policies and practices would have been helpful for biodigester facilities: having more specific federal and state level incentives and grant funding opportunities, higher prices for electricity they sell to utilities, assistance in receiving renewable energy credits, and less stringent permitting requirements. A very small percentage of the biodigester facilities have power purchase agreement with their utilities and most of those agreements are set to expire by 2023 that requires special policy attention.

A majority of the biodigester facilities in Wisconsin (who sell electricity) receive less than $0.09/kWh or less electricity rate, however; many of them think receiving a higher rate of electricity could help them reach the break-even or start making profit out of biogas operations. A small percentage of the biodigester facilities agree on having a better net metering law while a significant portion of the facilities neither agree nor disagree with this. However, many of the existing biodigester facilities agree on having a state-level mandate on electricity price that the biodigester could receive. Majority of the biodigester facilities agree on having a more supportive policy mandating food diversion from landfills and having a better national renewable fuel standard policy to assist biogas industries. In terms of return on their investments for biodigesters, a large portion of the facilities tend to be neither satisfied nor dissatisfied with the payback period for their biogas systems. Most of them are more likely to invest in another biodigester system.

Many facilities would like to make changes if they build another biodigester. Some of those changes would include: having better handling, mixing, separating and scrubbing systems, adopting better heating system, changing generator capacity, having the ability to better manage nutrients and substrates, and having renewable natural gas injection capability. Most of the facilities work closely with Wisconsin Department of Natural Resources (WDNR) and Wisconsin Focus on Energy program to operate the biodigesters successfully. A significant number

of biogas facilities show no interest in working with any organizations to receive biogas related assistance. For facilities interested in receiving assistance, the most named organizations, Focus on Energy, American Biogas Council, Wisconsin Biogas Council and UW-Madison Extension were cited most often. Most of them are interested in receiving financial assistance. Other support includes: technical, training, and supportive changes in state policies.

A small percentage of existing biodigester facilities in Wisconsin have become non-operational. The reasons for not having an operational biodigester include not making economic sense, lack of time or personnel, and not having a large enough system to produce biogas. Top challenges of having a biodigester include small-scale of production, low electricity rate contract, lack of knowledge on relevant policy and regulations, permitting issues, financing, and lack of expertise and help in grant writing process for funding. The biodigester facilities requested more grant funding opportunities to offset capital cost of biodigester installation, and supportive policies and incentives to promote this biogas industry in Wisconsin.

Biogas is a potential solution to help meet sustainability goals of Wisconsin communities that are focused on renewable energy and alternative fuels. This study will support Wisconsin's Clean Energy Plan (to be released 2021), a plan resulting from The Governor's Task Force on Climate Change Report.

Photo 9: Biogas system, Appleton Wastewater Treatment Plant, Appleton, WI

Many challenges that have been identified in this study including permitting, generator commissioning, nutrient management regulation, assistance from contractors or vendors, lack of support for funding and investments, net metering and renewable energy credits need to be addressed. Adequate supportive Wisconsin regulatory and tax policies, financial incentives, and investment options are necessary to stimulate the growth of biogas facilities. Policy consensus can help address the biogas challenges and utilize the full potential of strengthening local energy security, a stronger economy, a cleaner environment, and improved health in Wisconsin.

Significant challenges remain to ensure the sustainable and economical operation of biogas facilities in Wisconsin including:

- Insufficient policy support and incentive programs for biodigesters.
- Removing barriers to selling electricity or biogas to utility or interstate producers.
- Supporting cost-effective and safe operation of biogas electricity generators.
- Securing viable project financing.
- Establishing favorable environmental regulatory compliance standards and fair tipping fees.
- Enhancing public awareness, information sharing and inter-sector collaboration.

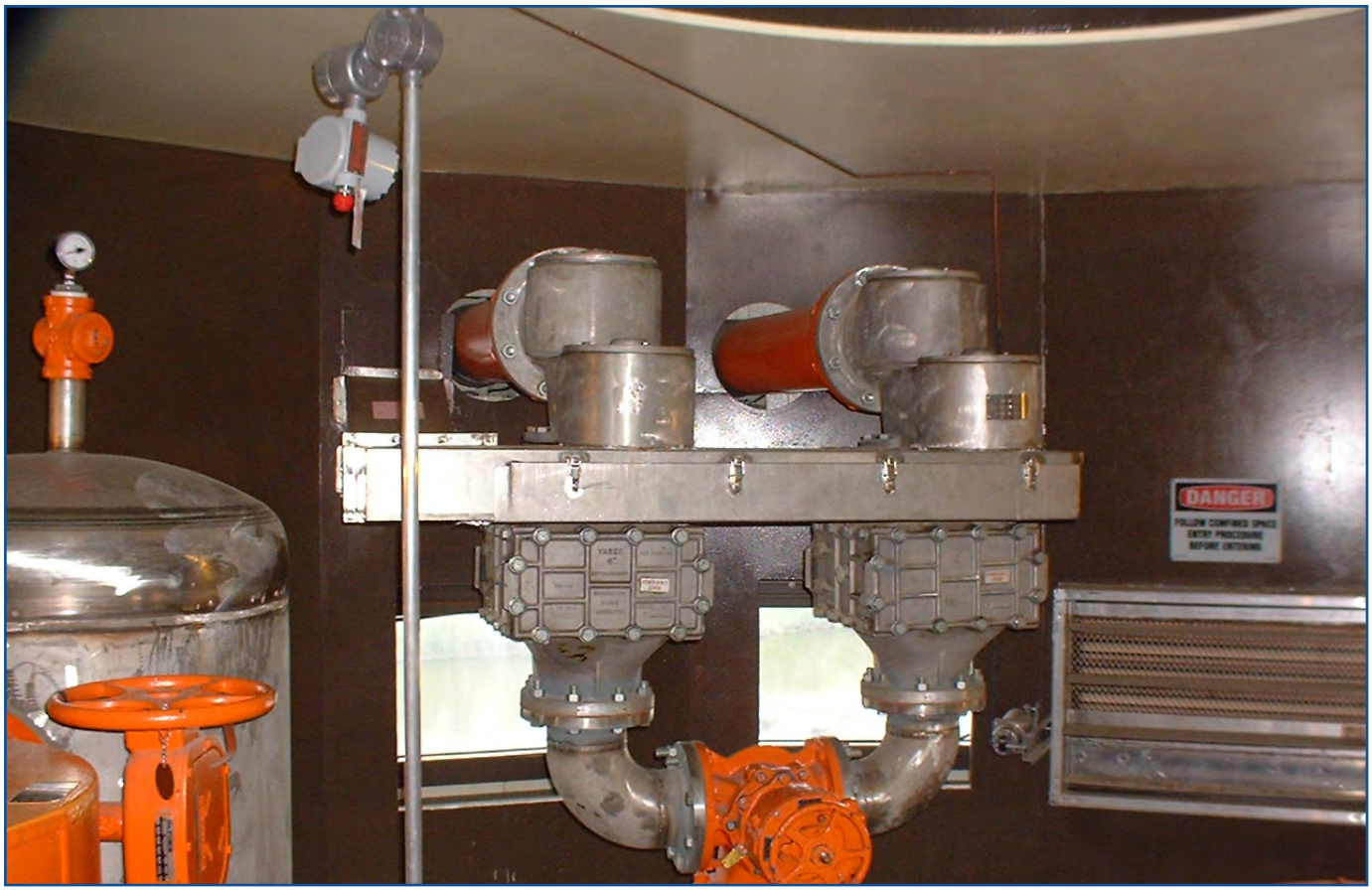
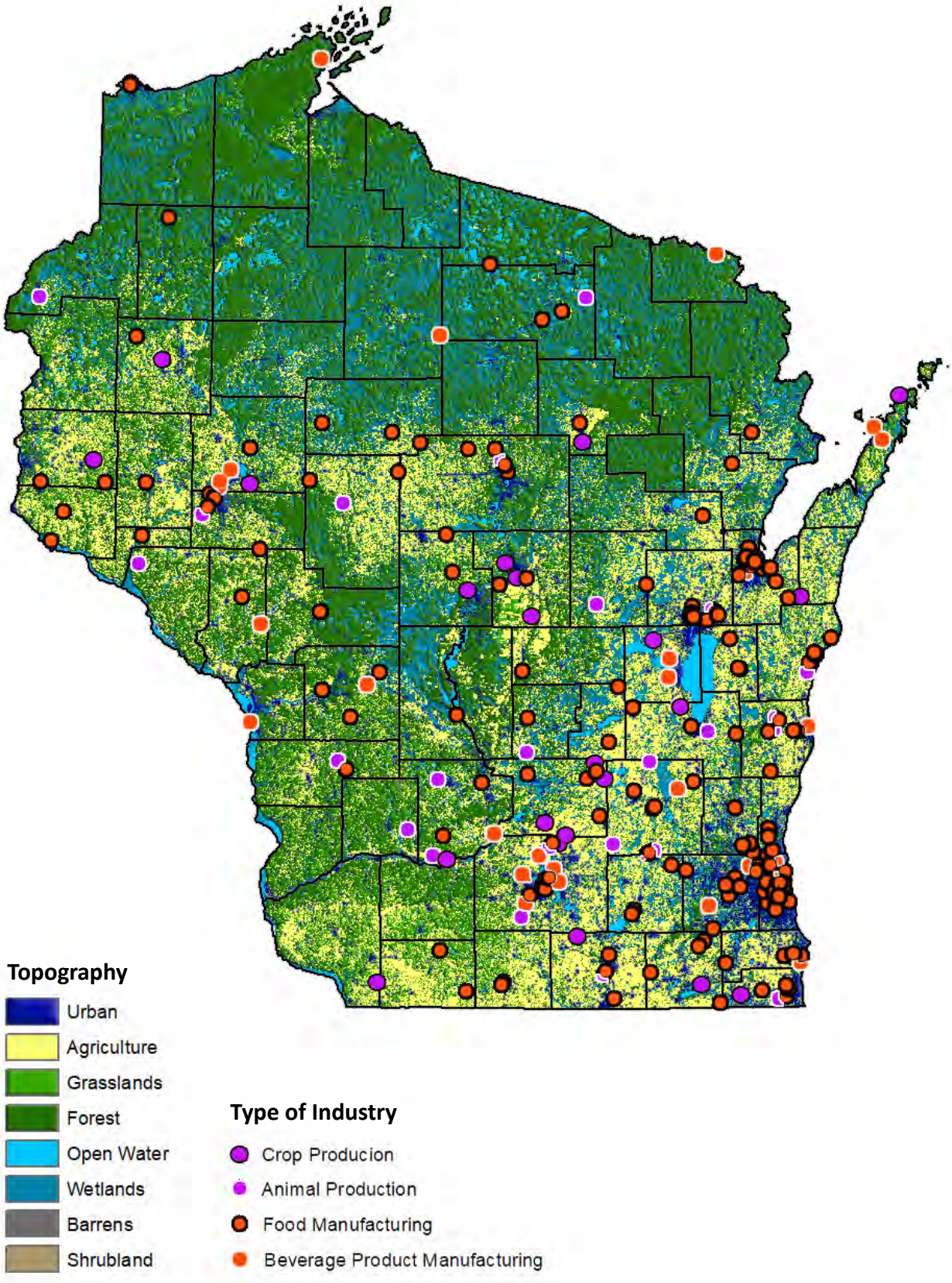


Photo 10: Gas pressure reducing regulator, Appleton Wastewater Treatment Plant



Map 5: Potential industries for biodigesters adoption

Appendix A

Biogas Facility and Feedstock Survey

Wisconsin Biogas Feedstock and Industry Survey 2020

On behalf of the Wisconsin Public Service Commission, Office of Energy Innovation, and Professor Dr. Shiba Kar at the University of Wisconsin-Stevens Point would appreciate your participation in this Biogas Study Survey designed to explore and assess the status, barrier and challenges of biogas facilities throughout Wisconsin. Your answers will help us better understand biogas facilities to develop a detailed Biogas report. The findings from this study will be used to address barriers and challenges of biogas industries and promote biogas production and use in Wisconsin.

The survey will take approximately 15-20 minutes. Please complete the survey to the best of your ability and submit it at your earliest convenience. If you are unable to complete the survey in one sitting, you may always stop and resume at a later time. Your participation in this study is completely voluntary.

If you have any questions, please contact Dr. Shiba Kar at skar@uwsp.edu or (715) 346-2359. If you would like to receive the results of our study, you will have the option to provide your email at the end of the survey.

When completed, please return the survey to us in the postage-paid return envelope.

If you prefer, you can complete the survey online at: http://bit.ly/38bY6FB.

or

Scan the QR code below to link directly to the survey:

Extension
UNIVERSITY OF WISCONSIN–MADISON

OEI
Wisconsin Office of Energy Innovation

Center for Land Use Education
College of Natural Resources
University of Wisconsin-Stevens Point

Section 1: General Questions

1. Which of the following sectors are you primarily involved with? (select all that apply)

	Farm - Agricultural crops
	Farm - Dairy
	Farm - Other livestock/CAFO
	Municipal wastewater treatment facility
	Food processing industry
	Industrial organic waste processing facility
	Landfill waste management facility
	Anaerobic digester sales/supply/installation

2. Which of the following statements best describes you? (select one)

	I am an owner
	I am a facility manager
	I am a biodigester operator
	I am a biodigester maintenance personnel
	I am a biodigester contractor

3. Does your facility have an active anaerobic digester to produce biogas?

	Yes
	No (go to Section 6)

Section 2: Biogas Facility and Feedstock

4. What year was the biodigester commissioned to start operation?

Enter the year:	

5. Rank the **top 5 motivations** for building a biodigester in your facility (1 being most important):

	Odor control and/or nutrient management
	Income from electricity or biogas sales
	Income from the sale of post-digested materials
	Reduced cost from on-farm electricity/renewable natural gas use
	Cost-effective treatment option for high strength wastes in non-farm biodigesters
	Tax reductions/credit
	Grant funding opportunity
	Outside investor's interest
	Wanting renewable energy in the facility
	Other (specify):

6. How important is your biodigester to a **successful farm or facility** operation? (select one)

	Not important		Fairly important		Important		Very Important		Extremely Important

7. How important is your biodigester to your **farm or facility income**? (select one)

	Not important		Fairly important		Important		Very Important		Extremely Important

8. What was the range of total cost of your complete biodigester- energy production system? Select one:

	Less than $100,000		$1,000,001 - $3,000,000
	$100,001 - $500,000		$3,000,001 - $5,000,000
	$500,001 - $1,000,000		More than $5,000,000

9. How did you build or install the biodigester system? Select one:

	Self-built
	By a biodigester company with monitoring/maintenance contract. Please provide the name and location of the biodigester company? (city, state, or indicate international):
	By a biodigester company without monitoring/maintenance contract. Please provide the name and location of the biodigester company? (city, state, or indicate international):

10. What is the capacity of your biodigester? (enter volumes applicable to your facility)

Biodigester Volume (gallons): the maximum amount of slurry the plant can hold	
Gas Storage Volume (cubic feet): the amount of gas it can hold when full of slurry	
Rated Daily Gas Production Volume (cubic feet): the amount of gas the plant is designed to produce each day	

11. What percentage of your complete biodigester-energy production system was offset by funding from grants? (non-loans)

	1 - 10%		11 - 20%		21 - 30%		31 - 50%		51 - 100%

12. What is the approximate daily loading of primarily used feedstock/substrate into the biodigester? (enter all that apply)

Manure from dairy cows (# of cows)		Check for seasonal variability	
Manure from beef cattle (# of cattle)		Check for seasonal variability	
Manure from swine (# of swine)		Check for seasonal variability	
Manure from poultry (# of chickens)		Check for seasonal variability	
Agricultural crop residues (tons)		Check for seasonal variability	
Food waste (tons)		Check for seasonal variability	
Municipal solid waste (tons)		Check for seasonal variability	
Municipal wastewater (gallons)		Check for seasonal variability	
Industrial high strength wastewater (gallons)		Check for seasonal variability	
Other (specify):		Check for seasonal variability	

13. What is the most used feedstock/substrate by volume? (select one)

	Manure from dairy cows		Food waste
	Manure from beef cattle		Municipal solid waste
	Manure from swine		Municipal wastewater
	Manure from poultry		Industrial high strength wastewater
	Agricultural crop residues		Other (specify):

14. Select all that apply to your biodigester facility relating to supplemental feedstock:

	We do not accept any supplemental feedstock from off-site (go to Question 17)
	We accept grease (municipal or industrial wastewater biodigester facility)
	We accept industrial organic wastewater (municipal wastewater biodigester)
	We accept food waster (farm biodigester facility)
	We accept agricultural residues (manure biodigester facility)
	Other (specify):

15. What is the source of the supplemental feedstock(s)? (select all that apply)

	Dairy farms		Brewery
	CAFOs		Supermarkets/grocery stores
	Agricultural farms		Schools
	Restaurants		Prisons
	Food processing industries		Other (specify):

16. Approximately, on average, how far does primary/ supplemental feedstock have to travel to get to your facility?

	All feedstock is available on-site		11 - 20 miles
	Less than 2 miles		21 - 50 miles
	3 - 5 miles		More than 50 miles
	6 - 10 miles		

17. Rank **any applicable challenges** your facility faces with feedstock acquisition (1 being most challenging):

	Cost of transportation
	Volume
	Quality of feedstock
	Contaminants in the feedstock
	Inconsistent timing and frequency of feedstock deliveries
	Storage
	Multiple supplier logistics
	Chemical or physical characteristics of feedstock
	Other (specify):

Section 3: Operations and Maintenance

18. How many staff are employed at your biogas facility to operate or monitor the anaerobic digestion system and processes?

Enter the number of staff:	

19. What is the yearly cost of system operation and maintenance?

	< $20,00		$20,000 - $49,999		$50,000 - $99,999		$100,000 - $150,000		> $150,000

20. Did you take any measures to make the biogas facility operation or maintenance more cost-effective?

	Yes (describe):
	No

21. Does your facility currently have a pipeline to inject biogas to intra- or inter-state natural gas pipelines?

	Yes
	No (go to Question 23)

22. Select all the statements that apply regarding your pipeline to inject biogas to intra or inter-state natural gas pipelines:

	It is important to operate the pipelines safely and maintain compliance (e.g. using the correct type of pipe, recording pressure test, becoming a member of the Digger's hotline 811, etc.
	We are aware of the Public Service Commission (PSC) pipeline safety team
	We have contracted or received help from the PCS pipeline safety team about pipeline construction and operation
	We have equipment constantly monitoring gas quality that automatically shuts off if unspecified gas is detected
	We measure BTU values before injecting into a distribution pipeline

23. Rank the **top 5 challenges** to your daily biodigester operation (1 being most challenging):

	Generator malfunction/maintenance
	Nutrient and/or odor management
	Metering
	Daily overhead costs for operation
	Cleaning up biogas for on-site use
	Transporting renewable natural gas (RNG) to injection point
	Variation in quality or quantity of biogas production
	Leaks in the system
	Foaming
	Overflowing
	Lack of operation and maintenance knowledge
	Lack of time to devote to operation and maintenance
	Other (specify):

Section 4: Production End Use

24. How much biogas does your facility produce on average per day in actual cubic feet?

Enter the amount in cubic feet:	

25. What is the average amount of end-use of biogas produced at your facility? (enter for all that apply)

Electricity (kWh)		Compressed natural gas (cubic feet)	
Heat for process (therms)		Pipeline natural gas (cubic feet)	
Facility heating (therms)		Flare (cubic feet)	
Co-generation of electricity and heat (therms)		Other (specify):	

26. What is the average annual amount of additional co-products generated by your facility and used on-site or sold off-site? (enter the amount for all that apply)

Bedding for livestock (cubic yards)		Wast heat recovery (therms)	
Fertilizer (cubic yards)		Liquid concentrated fertilizer (gallons)	
Compost (cubic yards)		Flush water (gallons)	
Other (specify):			

27. Do you sell biogas from your facility?

	Yes
	No (go to Question 29)

28. How do you sell your biogas? (select all that apply)

	On own, directly to the buyer
	Marketing through an intermediary
	Other (specify):

29. Does your facility currently have a nutrient management plan?

	Yes
	No

Section 5: Challenges and Policies

30. Rank the **top 5 challenges** you faced in your biodigester adoption as it relates to financing, construction, and implementation phases of your biodigester system. (1 being most challenging)

	Local opposition to siting
	Offtake agreement for biogas or co-products
	Bank financing
	Grant writing process
	Federal, state, or local funding delays or issues
	Grid connection and rate contracts
	Renewable natural gas upgrading
	Pipeline or gas grid integration
	Permitting
	Waste contracts
	Generator commissioning
	Nutrient management concerns or regulation
	Other (specify):

31. Rank the **top 5 resources** or assistance that were helpful in planning for the financing, construction and implementation phases of your biodigester system (1 being most helpful):

	Ease in working with bank financing
	Outside assistance (consultants with grant writing and funding
	Funding assistance (federal/state)
	Assistance from state and local officials
	Assistance from the biodigester vendor/utility company/biogas marketer
	Assistance from university extension personnel or eXtension resources
	AgSTAR or other federal online resources
	Past webinars or online resources
	Neighbor or colleague with biodigester
	Other (specify):

32. Rank the **top 5 policies or practices** that would have been the most helpful in financing, construction and implementation phases of your biodigester (1 being most helpful):

	Guaranteed low-interest bank loan
	More specific federal incentives or grant opportunities for biodigesters
	More state energy incentives or funding
	Policies to encourage more outside investors
	Less stringent permitting requirements
	Higher state mandated electricity prices
	Higher prices for renewable natural gas fuel
	Higher prices or assistance in renewable energy credits
	No changes to current policies or incentives
	Other (specify):

33. Do you have a Power purchase Agreement (PPA) with a local utility?

	Yes - Year PPA expires:		Name of the local utility:	
	No			

34. In 2020, what electricity rate did you get for electricity generated from your biodigester?

	Only flare or boiler		$0.07 - $0.09 /kWh
	Only on-farm		$0.10 - $0.12 /kWh
	Renewable natural gas only		> $0.13 /kWh
	$0.01 - $0.03 /kWh		Don't know
	$0.04 - $0.06 /kWh		Have a non-disclosure agreement with the utility

35. What electricity rate would you need to reach break-even or start making profit from your biodigester? (Not necessarily the rate you get, but the rate you think you should get)

Enter the electricity rate:	

36. Rate your level of agreement with the following statements:

	Strongly disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Strongly agree
We should have a better net metering law to support biodigester operation in Wisconsin	☐	☐	☐	☐	☐
There should be a state-level policy to mandate electricity price for biodigesters	☐	☐	☐	☐	☐
I would be supportive of policies that mandate food waste diversion from landfills	☐	☐	☐	☐	☐
There should be a better U.S. renewable fuel standard policy for assisting in biogas implementation	☐	☐	☐	☐	☐
I am satisfied with the payback period for our digestion system in terms of cost as determined by lifetime sales and savings	☐	☐	☐	☐	☐

37. How likely would you be to invest in another digestion system in the future?

	Not willing		Likely
	Unlikely		Definitely
	Fairly likely		No applicable/Don't know

38. Rank the **top 5 changes** you would make on your digestion system(s) if you had the resources (1 being most important)

	Changing electric generator capacity
	Adding renewable natural gas capability
	Better handling/mixing/separator/H2S scrubbing system
	Better heating system
	Different power purchase agreement
	Different substrates to put in the biodigester
	More time devoted to daily operation and maintenance
	Pre-treatment of substrates prior to digestion
	Better ability to manage nutrients in digestrate
	Other (specify):

39. Does your facility or business currently have a membership or work with any of the following: (select all that apply)

	American Biogas Council
	Wisconsin Biogas Council
	UW-Madison Division of Extension
	United States Department of Agriculture (USDA)
	Natural Resources Conservation Service (NRCS)
	AgSTAR by the Environmental Protection Agency (EPA)
	Wisconsin Department of Natural Resources (WDNR)
	Green Tier Legacy Communities (WDNR)
	Focus on Energy
	Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP)
	Other (specify):

40. Would you be interested in pursuing or receiving assistance with your facility's operations through any of the resources listed below? (select all that apply)

	American Biogas Council
	Wisconsin Biogas Council
	UW-Madison Division of Extension
	United States Department of Agriculture (USDA)
	Natural Resources Conservation Service (NRCS)
	AgSTAR by the Environmental Protection Agency (EPA)
	Wisconsin Department of Natural Resources (WDNR)
	Green Tier Legacy Communities (WDNR)
	Focus on Energy
	Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP)
	Other (specify):
	Not interested in pursuing or receiving assistance (continue with Section 7)

41. What type of assistance would your facility need most? (select one)

	Financial		Training and workforce development
	Technical		Other (specify):

(Skip to Section 7: Location and Contact Information if you have an active biodigester)

Section 6: Facilities With No Active Biodigester

42. Did your facility have an operating anaerobic biodigester within the last 5 years?

	Yes
	No

43. What are the reasons for not operating the biogas biodigester? (select all that apply)

	Does not make economic sense anymore
	Do not have enough time or personnel to monitor or manage
	Do not have enough technical support to keep up with engine and other maintenance
	Environmental quality issues
	Impacting other farm activities
	Unexpected events such as fire, lighting, etc. that caused damage
	Other (specify):

44. If you are interested in anaerobic digestion, rank the **top 5 greatest challenges** (real or perceived) to having a biodigester constructed for your operation. (1 being most challenging):

	Bank financing
	Time/help needed to write grants for biodigester funding
	Need for grant and funding assistance
	Time and knowledge needed to operate the biodigester once constructed
	Permitting concerns
	Too small of an operator to make a biodigester feasible
	Electricity rate contracts too low to be economical
	Challenges with upgrading to renewable natural gas and pipeline access
	Not aware of relevant policies or incentives
	Other (specify):

45. Rank the **top 5 policies or practices** that would be the most helpful in financing or implementing an anaerobic biodigester for your operation (1 being most helpful):

	Guaranteed low-interest bank loan
	Additional federal, state, or local grant opportunities for capital costs
	More Environmental Quality Incentives Program (EQUIP) funding
	More Rural Energy for America Program (REAP) funding
	Policies to encourage more outside investors
	Less stringent permitting requirements
	Higher state mandated electricity prices
	Higher prices for renewable natural gas fuel
	No changes to current policies or incentives
	Other (specify):

Section 7: Location and Contact Information

What is your zip code:	

Enter your email address:	

Check any that apply:

	I would like to receive more information or support from the Wisconsin Office of Energy Innovation (OEI).
	I would like to receive updates on the survey report.

Please include any additional questions or comments:

Please return the completed survey to us in the postage-paid return envelope.

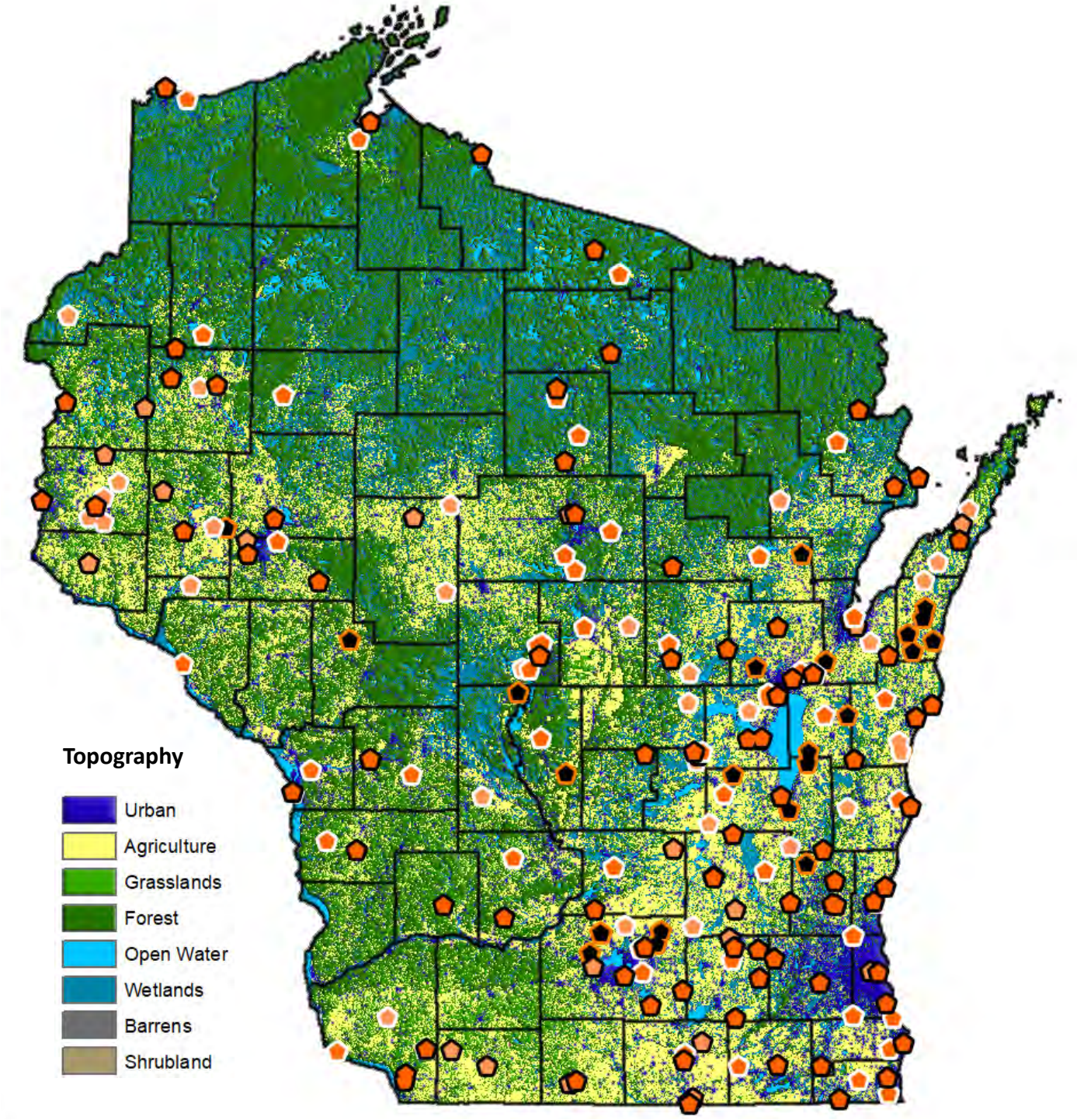
Appendix B

List of Biodigester Contractors

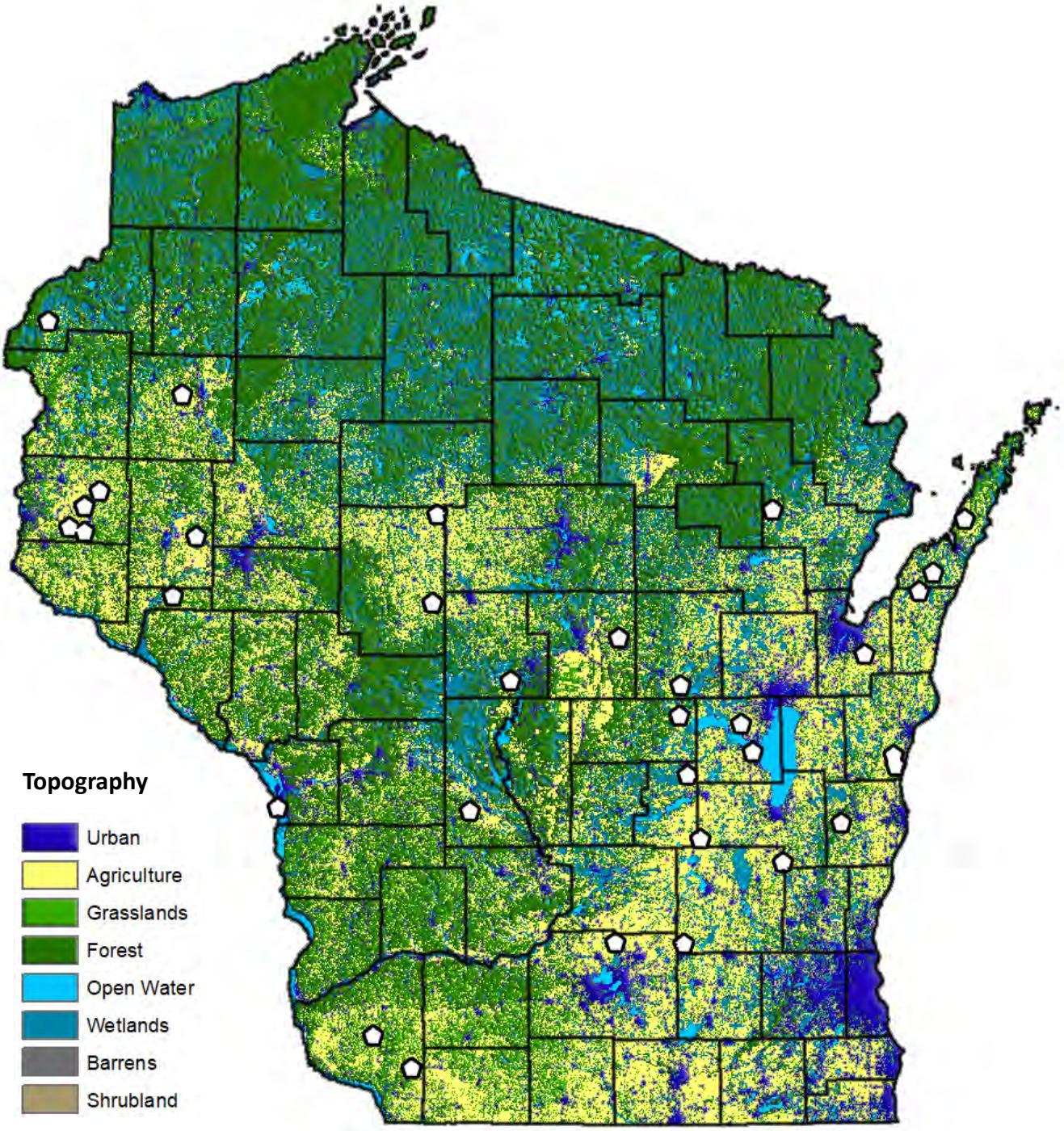
- City of Wisconsin Rapids Wastewater Treatment Facility
- Oconomowoc Wastewater Treatment Plant
- Voith-Meri Environmental Solutions
- Complete Filtration Resources
- Janesville Wastewater Utility
- DVO Renewables at Work
- BME Demeter RNG, LLC
- BioFerm Energy Systems
- Ecolab (international)
- Pagels Ponderosa
- Grant Grinstead
- NEW Water
- Duo- GHO
- GHD inc.
- Microgy

Appendix C

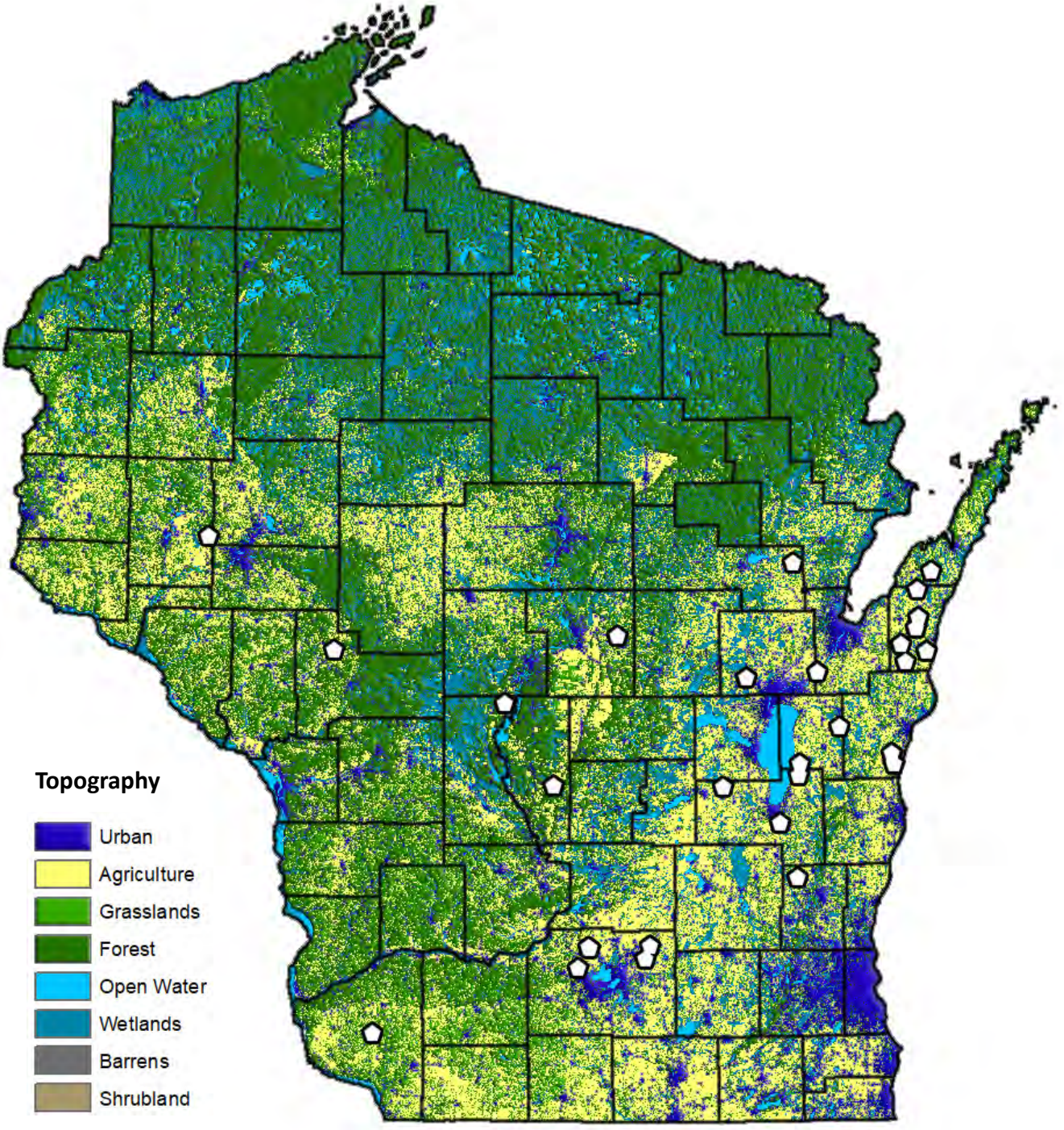
Maps



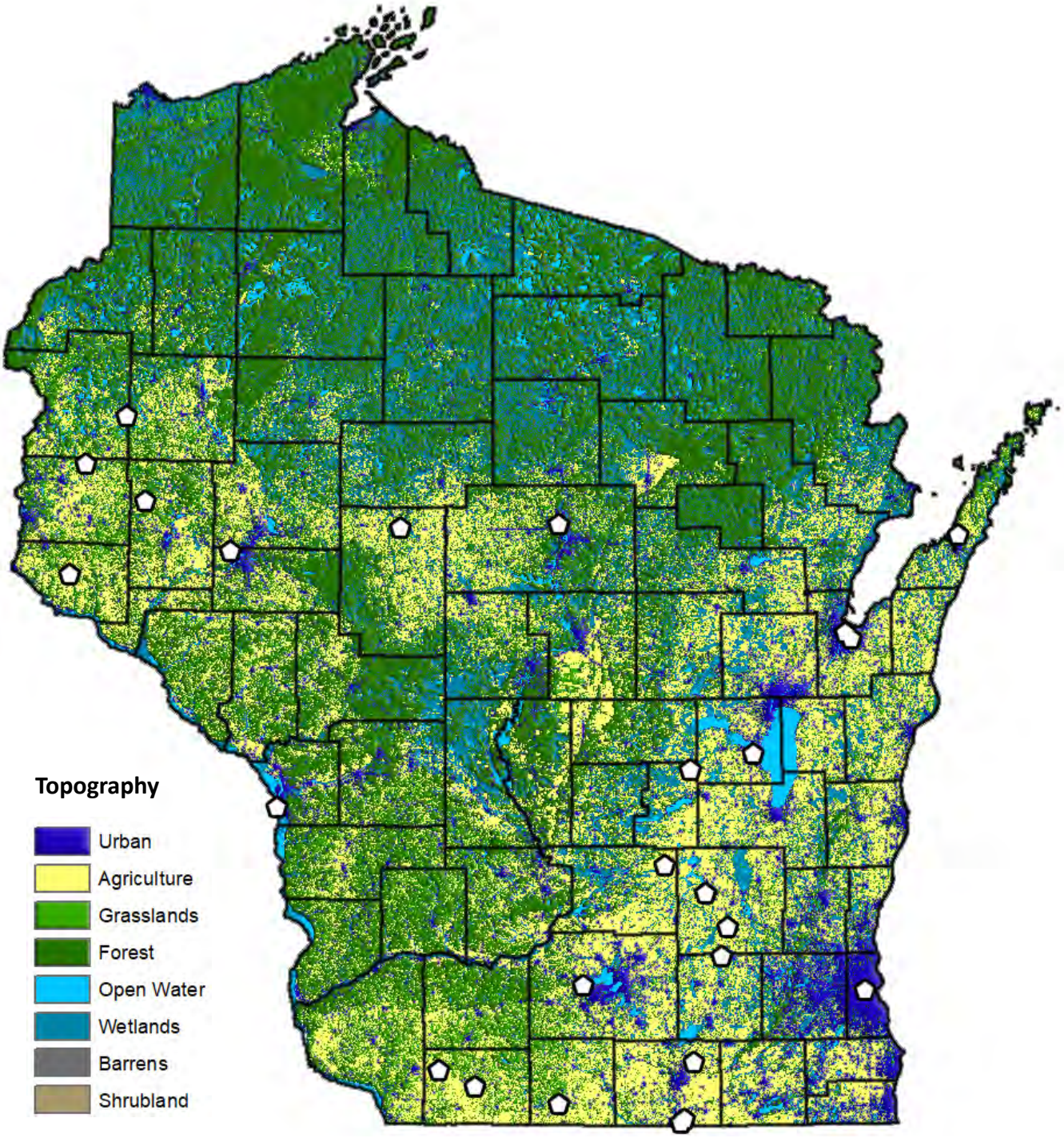
Map 6: Operational and nonoperational biogas facilities with email contacts (all sectors)



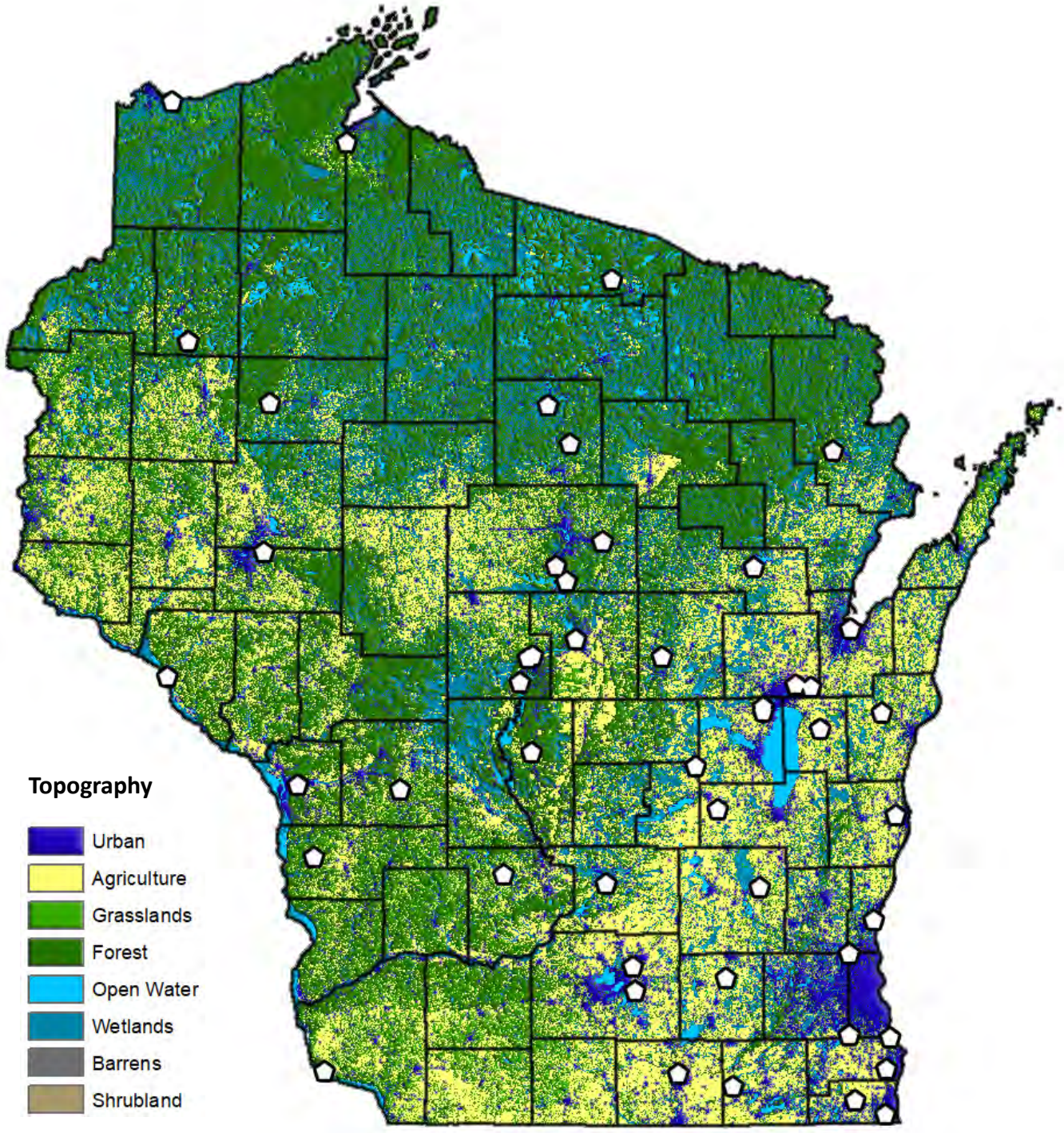
Map 7: Operational and nonoperational biogas facilities with email contacts (dairy)



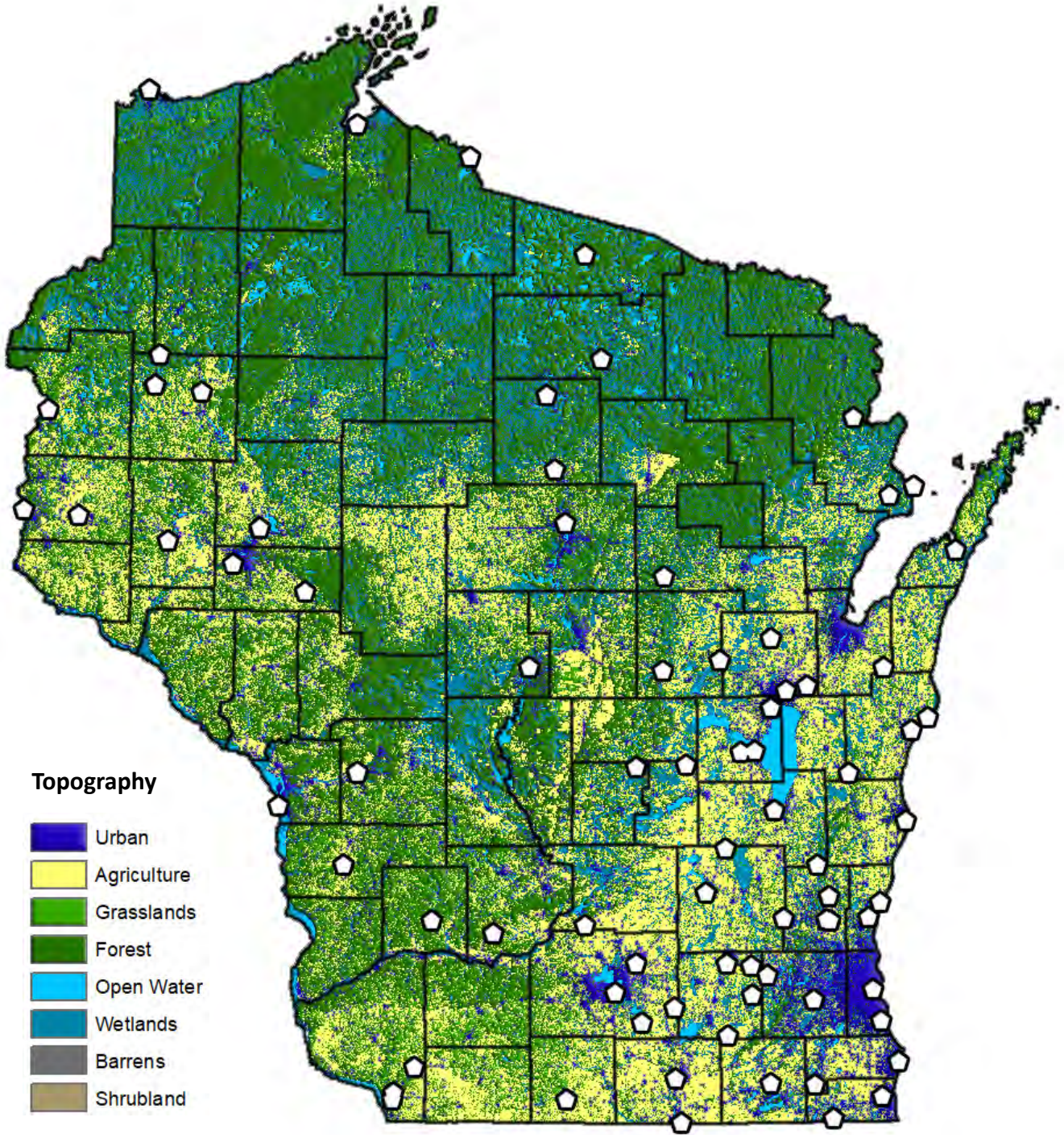
Map 8: Operational and nonoperational biogas facilities with email contacts (CAFOs)



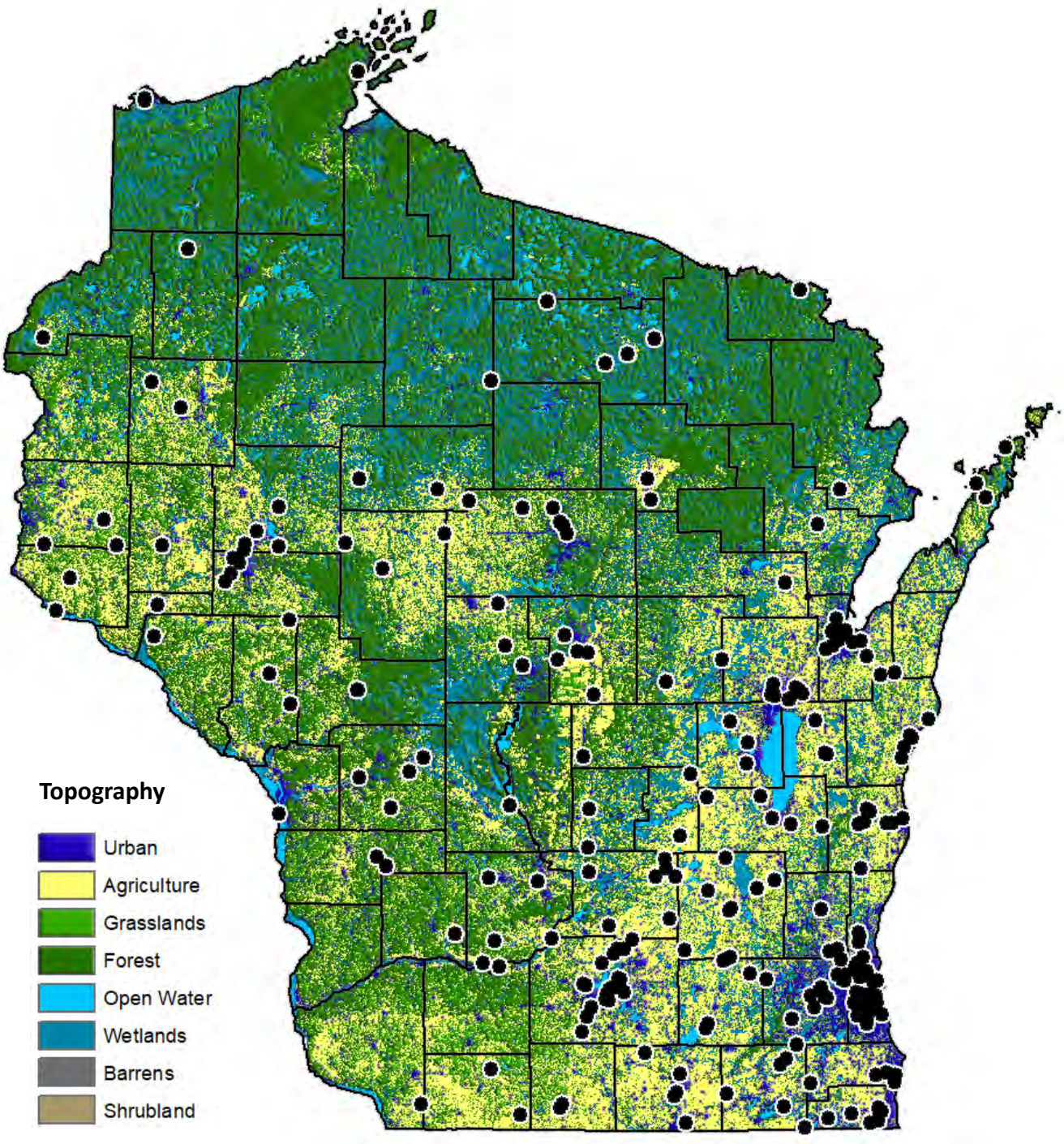
Map 9: Operational and nonoperational biogas facilities with email contacts (industrial)



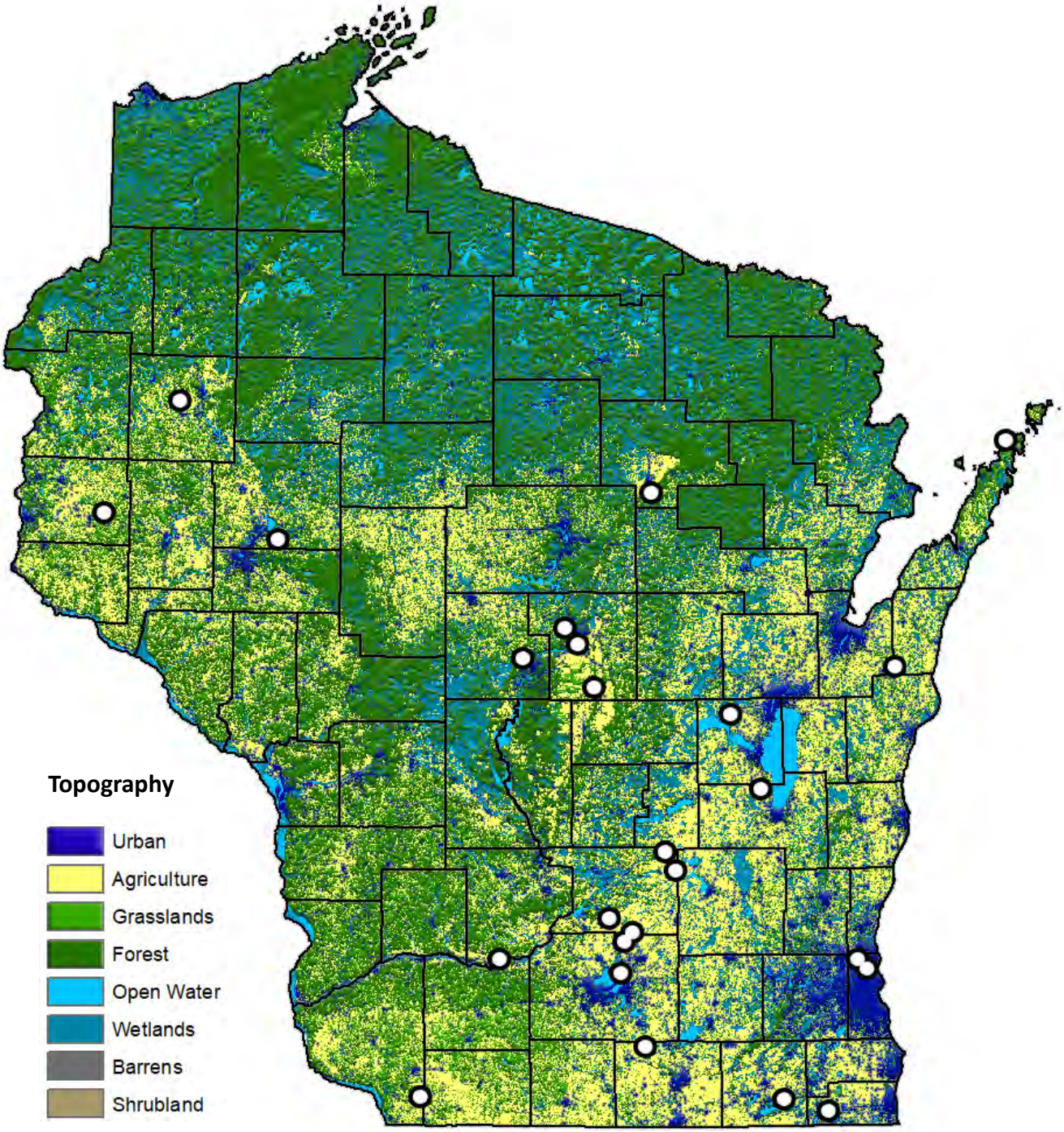
Map 10: Operational and nonoperational biogas facilities with email contacts (landfill)



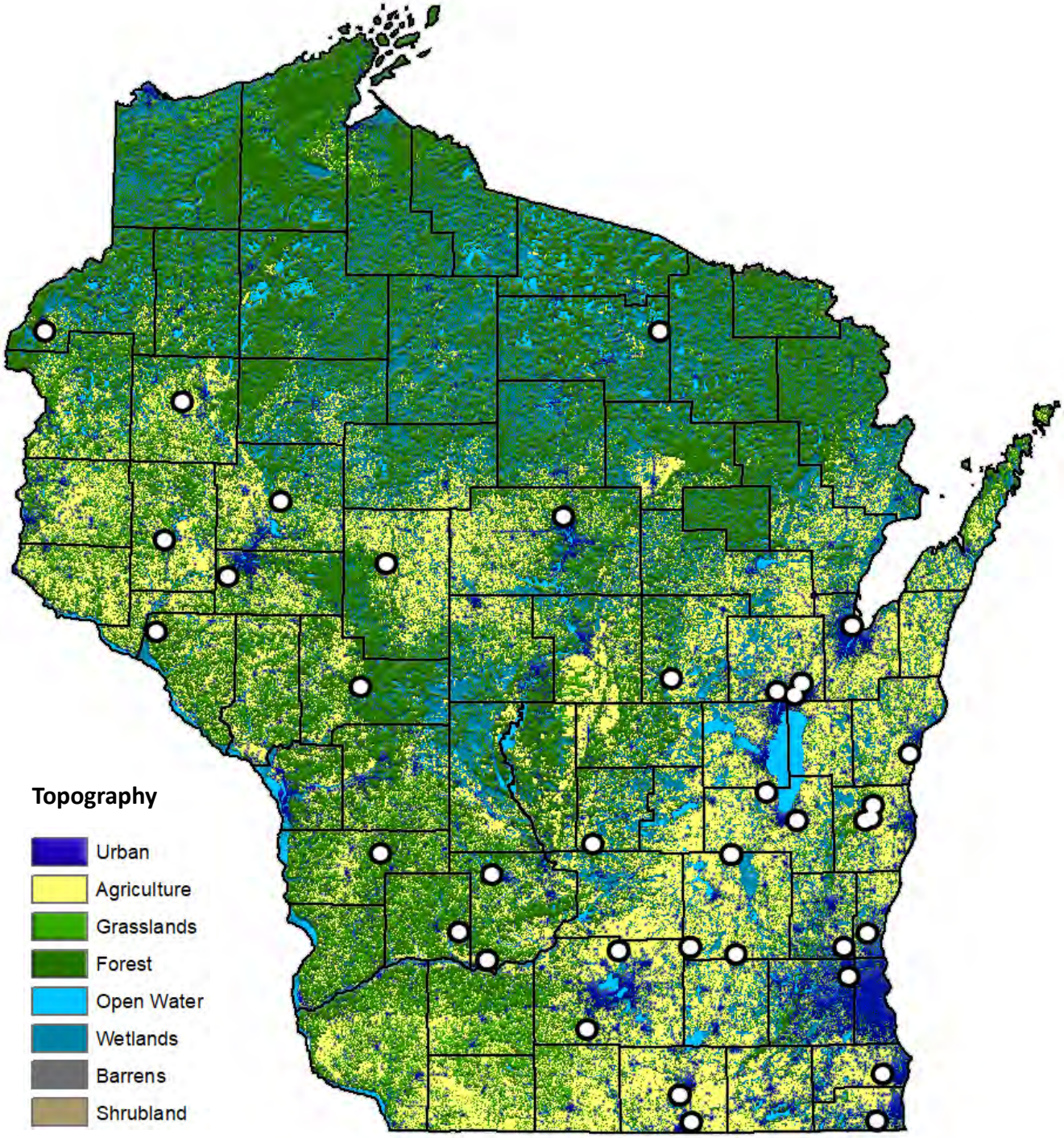
Map 11: Operational and nonoperational biogas facilities with email contacts (wastewater treatment plant)



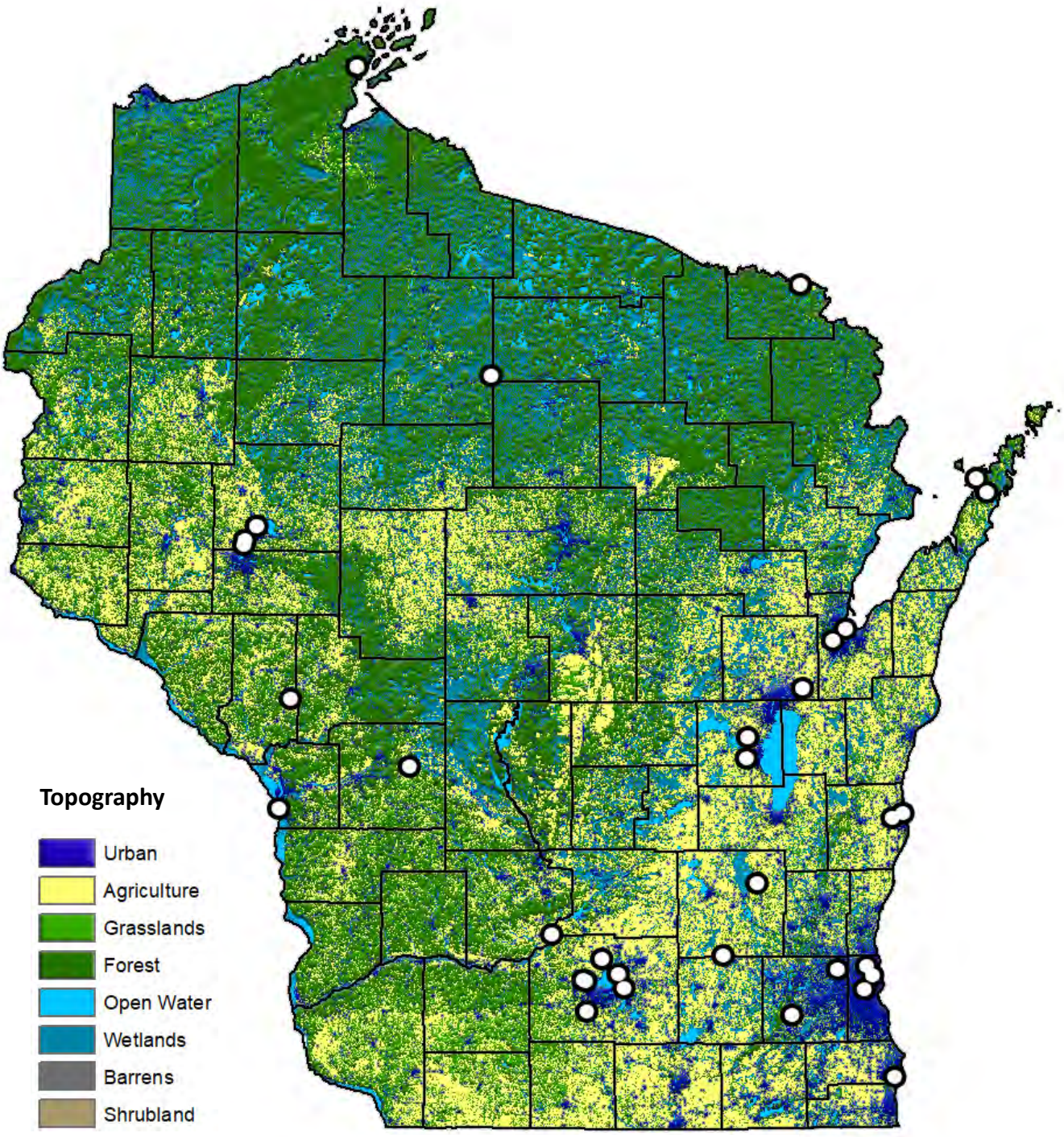
Map 12: Potential manufacturers who can adopt a biodigester



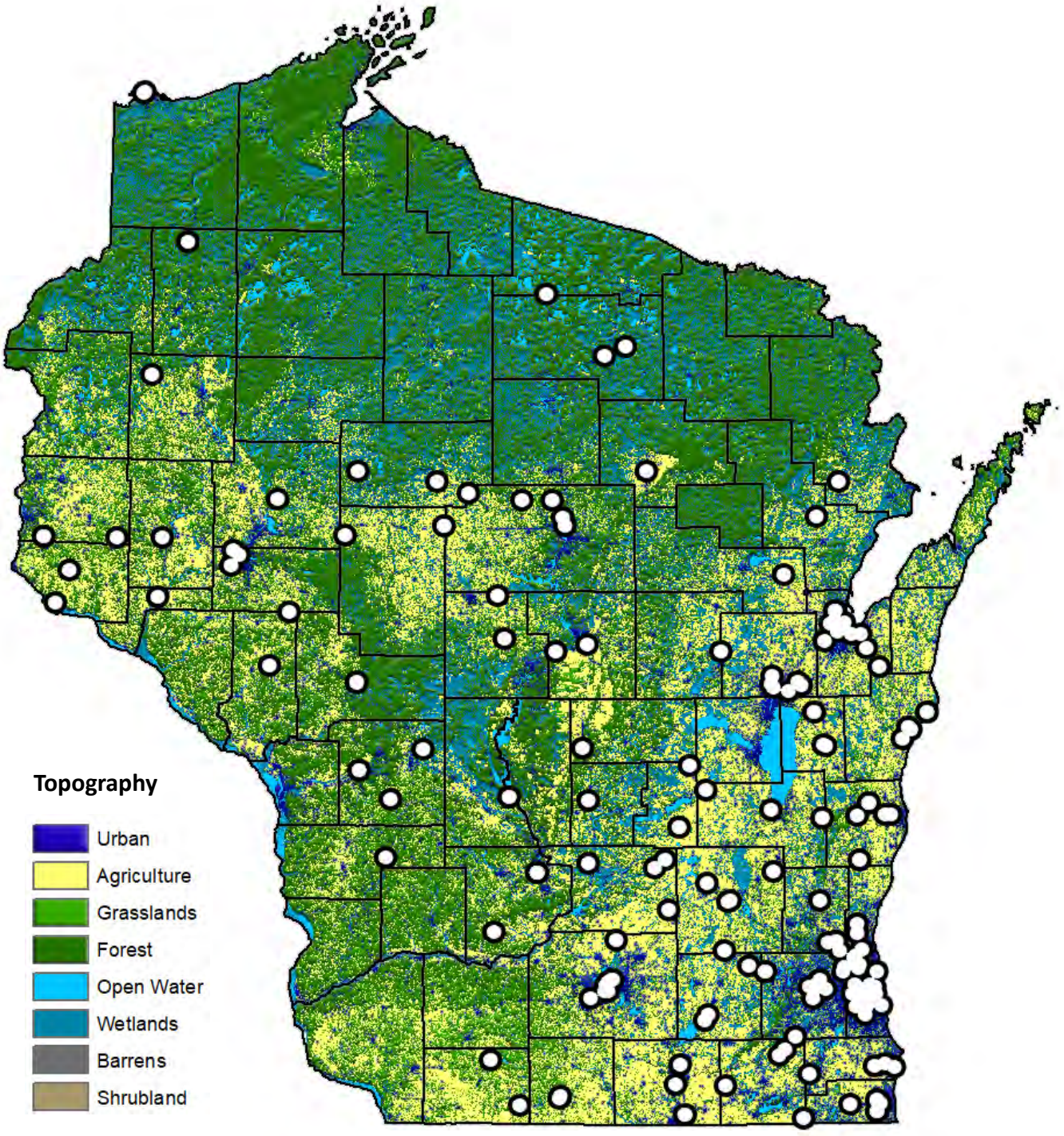
Map 13: Potential crop-based manufacturers



Map 14: Potential animal-based manufacturers



Map 15: Potential beverage-based manufacturers



Map 16: Potential food-based manufacturers

Appendix D

Relevant Resources and Policies

- *Biomass explained: Landfill gas and biogas*. Energy Information Administration (EIA) (2021). https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php (Accessed on 5/13/2021)
- *Fact Sheet | Biogas: Converting Waste to Energy*. (2017, October 3). Environmental and Energy Study Institute. https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy
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