Wisconsin Anaerobic Digester Operations
Dairy Industry Case Studies

Extension
UNIVERSITY OF WISCONSIN-MADISON

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

OEI
Wisconsin Office of Energy Innovation

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Preface and Acknowledgments

These case studies focus on three digester operations in the Wisconsin agricultural industry. They are a compliment to the Wisconsin Biogas and Feedstock Survey, a previous study conducted by the University of Wisconsin Center for Land Use Education, Public Service Commission of Wisconsin, and the Office of Energy Innovation (OEI) in 2022. 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 Lynn Markham, conducted these on-site agricultural visits. UWSP team members included Karen Blaha (UWSP Outreach Specialist), and Ryan Michalesko, (graduate student). The conclusion and opinions in this report are those of the UWSP team and not OEI or U.S. Department of Energy.

Finally, we thank the facility owners who took time to show us their digester operations and share valuable information for the successful completion of this project.

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Wisconsin Anaerobic Digester Operations

Dairy Industry Case Studies

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Cover Photo: Crave Brothers Farmstead Cheese, LLC, Waterloo, Wisconsin

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Introduction

This report serves as a follow up to the 2021 Wisconsin Biogas and Feedstock Survey.

In this report we explore how anaerobic digesters are being used in Wisconsin's agricultural sector today, including their advantages and disadvantages. We did on-site visits and interviews at two Wisconsin dairy farms with digesters and one multi-farm digester facility. We describe what has made these digesters successful, potential opportunities and roadblocks, and how they are choosing to move forward. We also provide a series of Wisconsin maps to take a preliminary look at the locations of dairy farms, natural gas pipelines, digesters, and the potential for renewable natural gas (RNG) production from dairy digesters.

Key Highlights

While the fact sheets for each digester facility provide the stories and details, here are a few highlights:

- Digesters can be integral to the operation of large dairy farms, providing electricity and heat production for the farm, cow bedding, more versatile separated fertilizers, odor reduction, etc.
- Some dairy farmers are operating and monitoring their digester facilities on their own, while other farmers are minimally involved in the digester facilities on their farm.
- Changes to Wisconsin energy policies have greatly reduced the profitability of burning biogas in generators to produce electricity and heat, leaving digester owners looking for other options.
- Switching biogas use from generators to produce electricity and heat, to cleaning the biogas to produce RNG, requires significant capital and increased operation and monitoring time and expertise.
- Companies that run RNG facilities are working with large dairy farms, or clusters of large dairy farms, near natural gas pipeline injection points. In 2022, Wisconsin had no small dairy farms producing RNG. The dairy farms producing RNG ranged from 1,700 to 9,100 cows per farm. Farms located farther from injection points on natural gas pipelines may also be less likely to benefit from RNG.

RNG transfer to truck for transport to pipeline injection point, EnTech Solutions, Town of Springfield, WI

Biogas Background

Biogas can be produced from plant or animal-based materials including animal manure, unused food, agricultural residues, energy crops, industrial organic byproducts, and municipal sewage sludge. Through a process called anaerobic digestion, 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.[1]

Wisconsin is one of the early adopters and leading states in the nation to produce renewable energy from anaerobic digestion systems.[2]

The state ranks number three, just below California and Idaho, for potential energy generation from dairy manure, according to a report by the U.S. EPA.[3] The report further identifies 358 candidate dairy farms in Wisconsin and the potential to reduce their methane emissions by about 85 percent.

Anaerobic Digesters Located on Larger Farms

In 2022 Wisconsin had 323 dairy confined animal feeding operations (CAFOs) and a total of 32 other CAFOs, including swine, beef, turkey, chicken, and duck CAFOs.[4] Map 1 identifies CAFOs by animal type. Map 2 shows dairy CAFOs by animal units per county.

Appendix A contains additional maps showing the size of individual dairy CAFOs by animal units, dairy CAFO animal units per county, and the percent of total dairy cows in CAFOs per county.

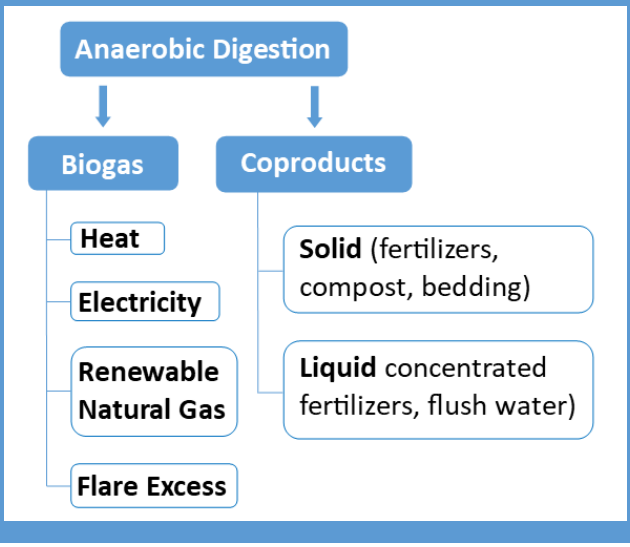
The AgSTAR Livestock Anaerobic Digester voluntary database lists 43 Wisconsin dairy digester facilities that are operational, which range in size from 130 to 9,100 cows per facility with a median of 2,100 cows per digester facility. Wisconsin has 22 dairy digester facilities producing electricity and/or heat from biogas that ranged from 130 to 8,500 cows per facility with a median of 1,950 cows. The 11 existing dairy digester facilities producing only Renewable Natural Gas (RNG) ranged from 1,700 to 9,100 cows per facility with a median of 4,000 cows. Two Wisconsin dairy digester facilities are under construction to produce RNG with sizes of 5,200 cows and 30,000 cows per facility.[5]

Some Wisconsin digester facilities process manure from multiple farms. The EnTech Solutions Middleton digester facility in Dane County gets manure from four farms and the BC Organics digester facility under construction in Brown County will get manure from 11 farms.[6]

Figure 1: Biogas quick facts

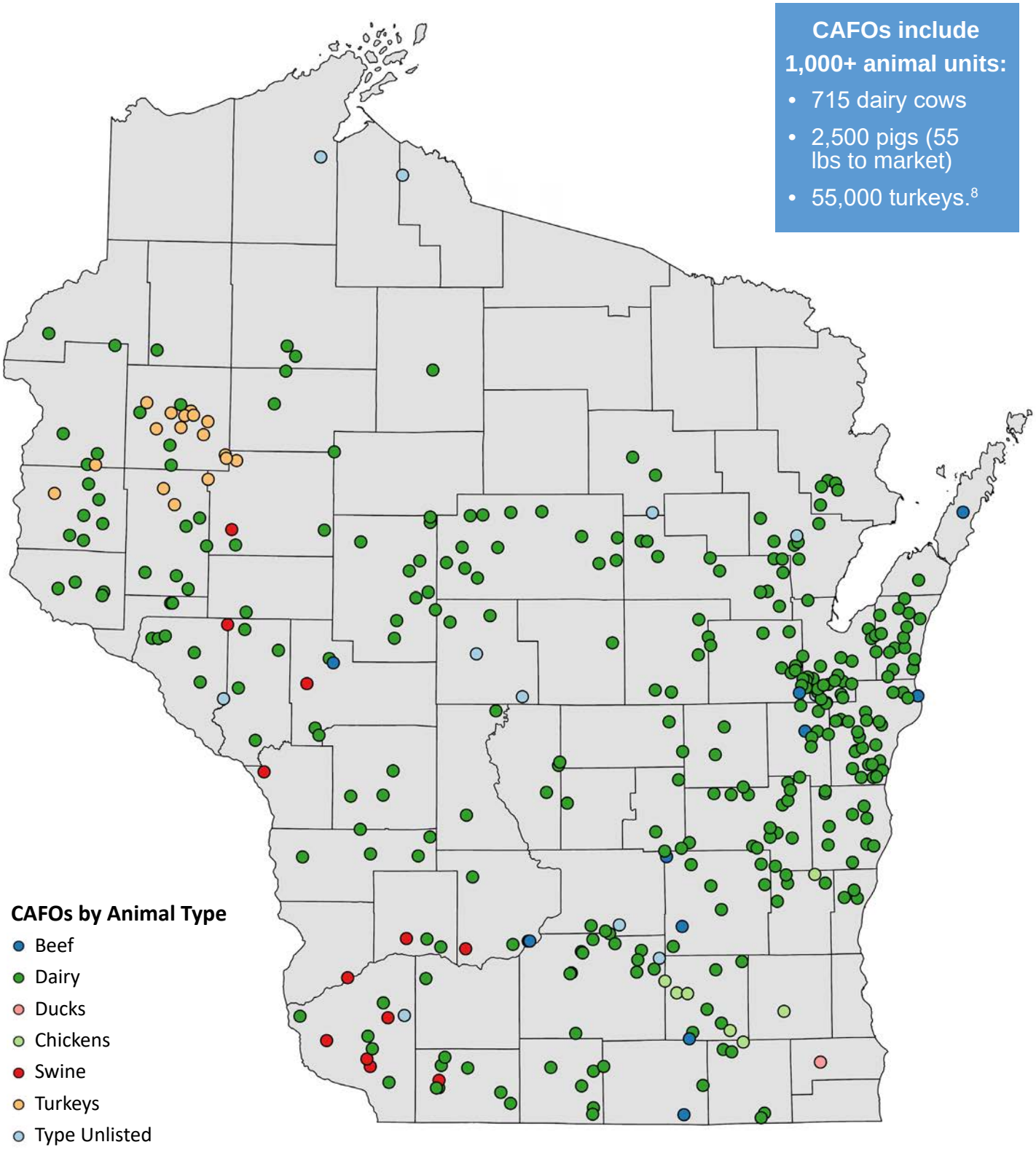
Biogas Quick Facts

- Typical biogas contains two-thirds methane, and about one-third of carbon dioxide with a small percentage of other gases such as hydrogen sulfide and carbon monoxide.[7]
- Biogas can be used to produce heat and/or electricity.
- Bio-methane, also called Renewable Natural Gas (RNG), can be produced by removing carbon dioxide and other gases.
- RNG can be injected into natural gas pipelines (if infrastructure is available) or compressed and used as fuels for vehicle engines.

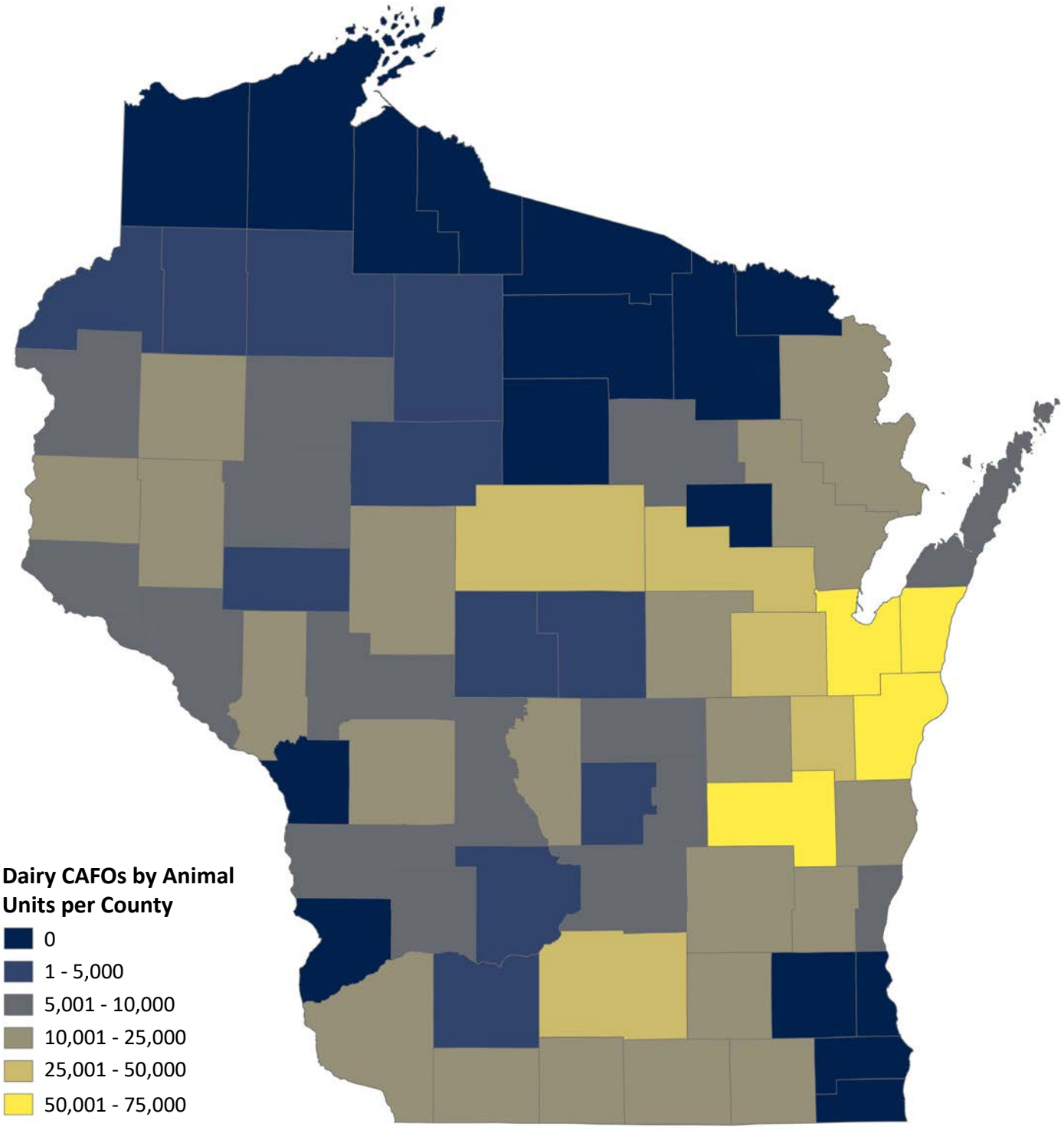


CAFOs include 1,000+ animal units:

- 715 dairy cows
- 2,500 pigs (55 lbs to market)
- 55,000 turkeys.[8]



Map 1: Wisconsin CAFOs by animal type[9]



Map 2: Dairy CAFOs by animal units per county[9]

Most of the northern forested counties and four southeast counties have few or no dairy CAFOs. Highest dairy animal units per county on CAFOs are found in Brown, Kewaunee, Manitowoc, and Fond du Lac counties These counties each have between 50,000 and 75,000 animal units which is equivalent to between 35,751 and 53,625 cows per county. Dane, Marathon, Shawano Outagamie, and Calumet – each have an equivalent of between 18,786 and 35,750 cows per county.

Table 1 summarizes the potential advantages and disadvantages of biogas production.

Table 1 : Potential advantages and disadvantages of biogas production

Potential Advantages
• Local, clean, reliable energy production
• Positive public image from reduced odor helps farmers maintain good relationships with their neighbors
• Additional income stream for farms (unknown amount)
• Local jobs operating and monitoring biogas production
• Reduced greenhouse gas emissions compared to CAFOs without digesters
• Digester solids can be used for animal bedding or compost
• Digester liquids contain more versatile nutrients than raw manure. Nutrient quantity remains unchanged. See Appendix B: Digester Impacts on Nutrients in Manure for additional information.
• Reduced pathogens in manure
Potential Disadvantages
• RNG credits do not currently help smaller dairy farms or farms that have cows outside. Credits or other incentives that encourage further concentration of livestock and manure in one area may negatively impact nearby drinking water, streams and lakes. The median size dairy digester facility producing RNG in Wisconsin uses manure from 4,000 dairy cows.
• If manure is trucked to a digester and liquid digestate trucked back, heavy truck traffic increases, resulting in greater local government costs for road maintenance. Spills may also happen during trucking.
• High pressure RNG/methane may leak to the atmosphere

Dallman East River Dairy

Digester switches from electricity to renewable natural gas

Underground Biodigester, Dallman East River Dairy, LLC, Brillion, Wisconsin

The manure digester on Matt Dallman's farm isn't new. But the digester producing renewable natural gas (RNG) is. When talking about the switch from producing electricity to producing RNG, Dallman says "It's definitely the way to go. A lot more money to be made with RNG."

In 2012 DVO, Inc. installed the manure digester on Dallman East River Dairy to produce electricity. DVO owned and operated the digester, and sold the electricity. Producing electricity was profitable, as the utility paid 15-16 cents per kilowatt hour (kWh). "When it went down to two to three cents per kWh, there was no way," said Dallman.

After selling electricity became unprofitable, DVO sold the digester to U.S. Gain in 2019. U.S. Gain added equipment to clean and compress the biogas to create RNG. They operate and monitor the digester and sell the RNG. U.S. Gain gets a much higher price for the RNG than regular natural gas due to renewable energy credits from California's Low Carbon Fuel Standard (LCFS) in combination with the federal Renewable Fuel Standard.

"It's nice to see the methane getting used for gas [RNG] production, rather than going up in the air," Dallman said of the digester. "Using it to make more energy here in the U.S. is definitely a plus."

Farm Facts

4400 milking cows

Digestate by-product for cow bedding

Digester

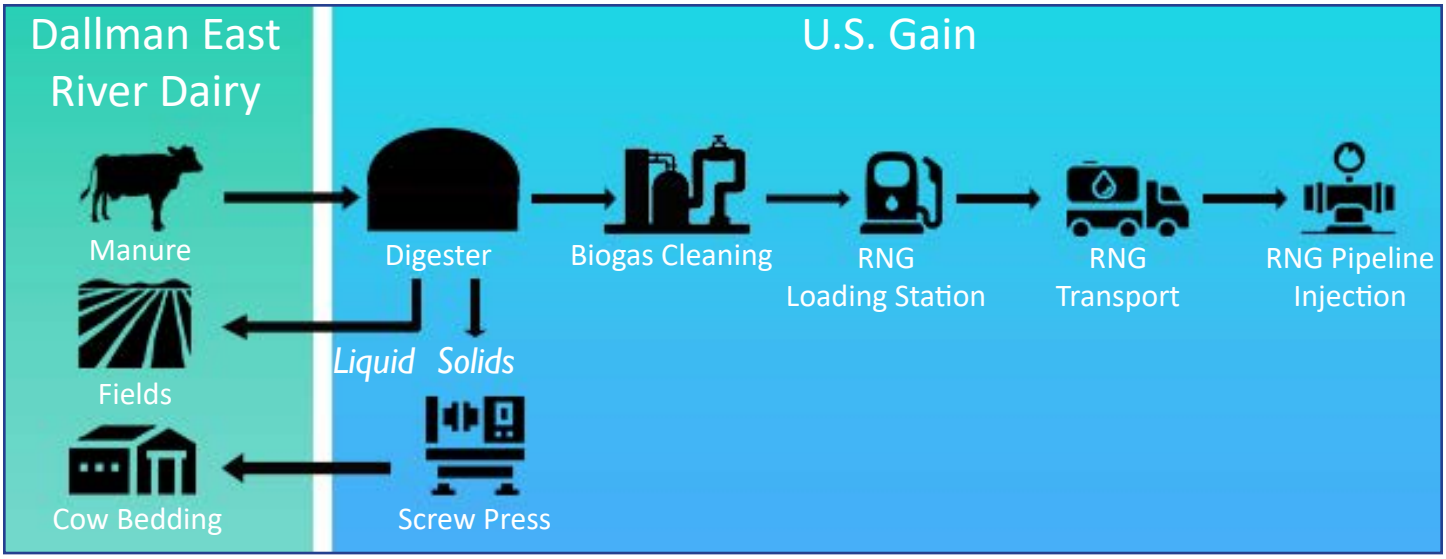
1.8 Million gallon DVO underground digester

On-site biogas purification

RNG compression and loading site

RNG production proprietary

Dallman East River Dairy cows



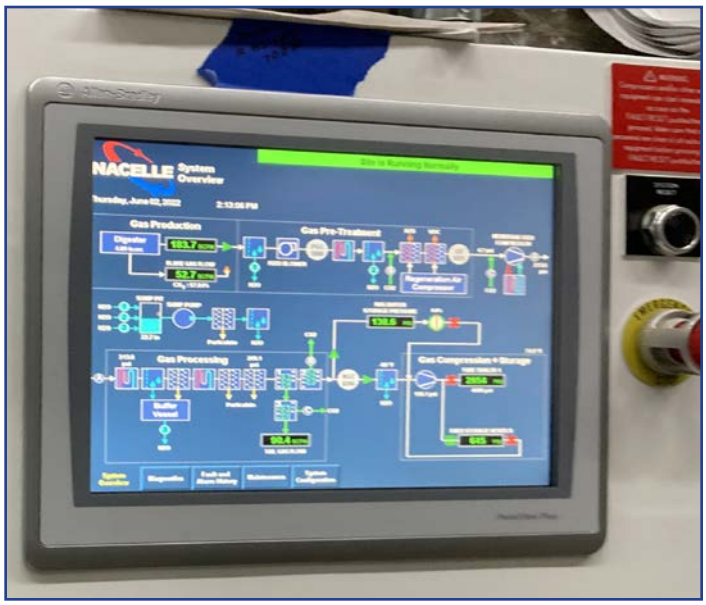
Dallman Farms RNG Production Process[10]

U.S. Gain has installed monitoring equipment to track volume, temperature and more in the digester and gas cleaning equipment, allowing them to increase gas production and decrease gas contaminants. According to Pat Van Dehy, U.S. Gain's director of operations, "Dallman has continued to evolve and produce more gas at less cost over the last two years we've been operating. Gas production is growing every week here."

After the manure goes through the digester, some of it goes through a screw press separator to remove the solids so they can be used for bedding. "We use the digestate for bedding, and we do sell some of it. We sell probably 30-40% to nearby farms and use the rest of it ourselves," said Dallman. In the past, Dallman was buying sand for bedding.

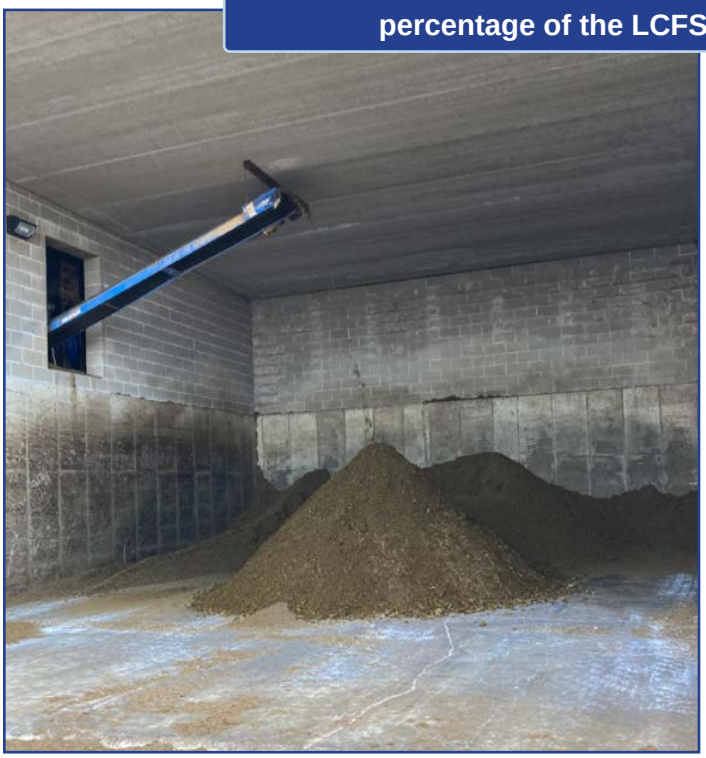
The RNG from Dallman Dairy is trucked eight miles to Holsum Dairy, Elm Farm. At Holsum, the RNG from Dallman Dairy is injected into the natural gas pipeline through an interconnect installed by Holsum. RNG from two Holsum dairies with a total of 10,000 cows is also injected there.

Digester heat pump monitoring



RNG process monitoring

U.S. Gain is interested in developing more RNG projects on farms with 3000 cows or more. Clusters of farms are also of interest. Hardy Sawall, U.S. Gain RNG director of business development, shared that U.S. Gain's RNG deals with farmers range from fixed payments over the year, to sharing a percentage of the uncleaned gas plus a percentage of the LCFS credit, to a 50-50 venture.



Top: Holding tanks for RNG awaiting transport; Left: Biodigester digestate by-product for cow bedding; Right: Transfer station to load trucks for RNG transport to injection site

Crave Brothers Farm

Digester System Integral to their Farm

Digestate Barn, Genset & Digester, Crave Brothers Farmstead Cheese, LLC, Waterloo, WI

When Jordan Crave, Crop and Forage Manager at Crave Brothers Farm, described the manure digesters on their farm, he said they are "very integral to what we're doing." The digester system provides a number of functions: reduces and controls on-farm odors, creates versatile separated fertilizers, and produces biogas that is used to generate electricity and provide heat for the farm buildings and for the digestate dryer which yields high quality cow bedding.

The Crave Brothers Farm first had a manure digester and generator (genset) installed in 2006 to create electricity. Their Purchase Power Agreement (PPA) with We Energies to buy the electricity they produce ran from 2006 through 2022 without a change in price per kilowatt hour (kWh). Now that their PPA is coming to an end, the Craves are in the process of deciding what to do next with their digester system. Specifically, whether to keep producing electricity, or switch to producing renewable natural gas (RNG).

Initially the digester system was a partnership with other companies, which the Craves found very beneficial. A few years ago the Craves decided to put in the bedding dryer system heated with biogas and really go to the next step. Their partner wasn't interested in this addition, so the Craves bought the digester system – two 750,000 gallon digesters and a 633 kilowatt genset – and took over its operation.

Farm Facts

3,800 milking, dry cows, and heifers

Two 750,000-gallon digesters

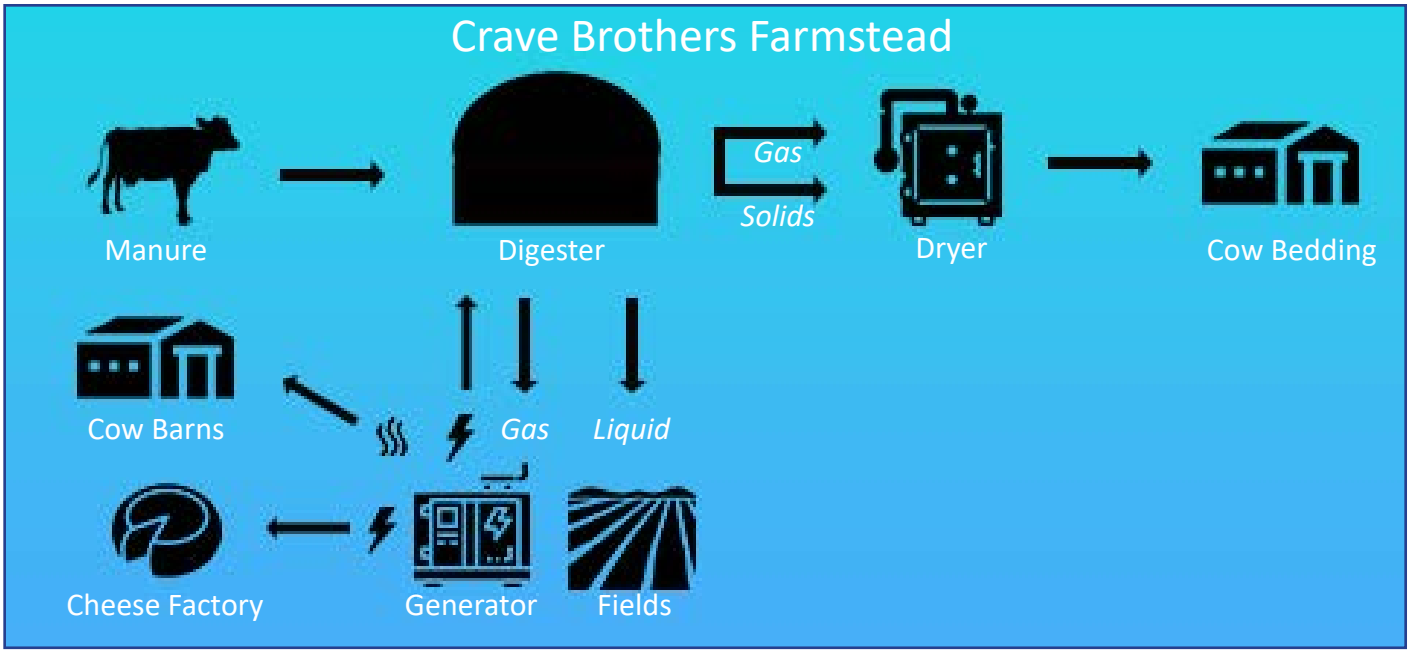
633 kW genset produces electricity for the farm, cheese plant, and grid

Bedding dryer powered by biogas

Digester provides cow bedding, odor reduction, versatile nutrients and heat

Crave Brothers Farm Dairy cows

Connected Digester Benefits



Crave Brothers Farm Biodigester Connectedness[11]

While deciding how to proceed with their digester, the Craves are considering many of the following connections that their digester system has with their farm, their cheese factory, and their community.

Cow Bedding

The Craves use wet and dried digestate as cattle bedding, eliminating the cost of purchasing and trucking in alternative bedding like sawdust or sand. In 2018 they installed a rotary drum dryer fueled with biogas from the digester to dry bedding.[12]

Crave explained, "We take the digested manure, screw press it, down to this wet fiber product, which is about seventy to seventy-two percent moisture and then we can either drop that in a pile and use it for wet bedding which we do on our young stock, our heifers. We usually just bed them with wet or we feed it into our dryer [made in Watertown, Wisconsin] and dry it down to about fifty-five percent [moisture], which works really, really well for the cows. Two things [are] the quality of the bedding in the stalls so it doesn't pack, and get as tight, it stays fluffier, softer. But then a big part of it is udder health – mastitis, bacteria. By drying it down and heating it up it really, really creates a pretty sterile product. It's very comfortable and absorbent. It does a really nice job."

The Craves produce enough bedding each week to serve their 3,800 cattle. In addition, "We've been selling a little [bedding] the last few weeks, which has been really great. …. We're getting more bedding, getting good electricity, hitting a lot of our goals," said Crave. Many other farmers want to learn about bedding dryers, and the Craves report about a farmer a week comes to see theirs in action.

Odor Reduction

Crave said, "So for me the odor thing is something that I need to acknowledge because they [neighbors] just become accustomed to it. …When we apply [digested manure] on the land, I get generally very good feedback from landowners and from neighbors. I mean, they know you're spreading. They say to them usually it smells like compost. It just smells kind of earthy. It's not like close the windows and leave town for a week."

More Versatile Fertilizers

My main responsibility is the agronomy," Crave pointed out. "I manage all of our field operations, agronomy, nutrient management. So from that standpoint, it [the digester] really helps me with phosphorus management. A lot of the phosphorus is contained in those solid portions. So by us taking three semi loads [of dried solid digestate] a week over to the other dairy, bedding with it, it goes into that pit, gets mixed in with that manure and gets used on that other farmer's land base. It gets him phosphorus that he needs because he doesn't have manure, and it pulls some levels of phosphorus out of my product."

"From the agronomy standpoint," Crave continued, "I really, really like the way a digester with separation helps. By changing the dry matter content of the manure and changing the nitrogen profile, it makes the fertilizer source that I have much more versatile. So we're applying our manure in sort of different ways than traditionally speaking… Now we're able to come out in the fall and transition from one crop to another. So we'll plant the cover crop right away after we harvest corn - either a triticale or rye. I'll be planting that and let that green up, and then we'll come back and apply the manure on top of that crop.

"The Craves use wet and dried digestate as cattle bedding, eliminating the cost of purchasing and trucking in alternative bedding like sawdust or sand. In 2018 they installed a rotary drum dryer fueled with biogas from the digester to dry bedding."[12]

Left: Digestate screw press; Right: Digestate dryer; Bottom: Dried digestate delivered via conveyor belt from the dryer

So we're just absorbing and utilizing nutrients so much better. … This [digested manure] absorbs and infiltrates into the soil really readily, really easily. The nitrogen is very easily taken up by plants, so it just really pairs super well with our cropping system. If we had to go back to square one and just dump it in a manure pit, I would have to start really rethinking how I'm handling manure. It [digested manure] becomes much more versatile and useful to me. I can apply it on hay crops and hayfields without burning plants."

633 kW Genset

Heat

"We're using a lot of heat off the engine to heat our shop, all the tanks, and some of our buildings," said Crave.

Electricity

The 633 kW genset running on biogas produces enough electricity to power Crave Brothers Farm, Crave Brothers Farmstead Cheese (which is labeled as produced with 100% green power).

Crave said "We're producing electricity. It's hitting the grid. Everyone's using it [gesturing to nearby homes and farms]. We don't need transmission lines this big coming from ninety-five, one hundred and fifty, two hundred, and five hundred miles away. The electricity just goes out, gets used. …to me the electricity is more beneficial, more practical, and useful [than RNG]."

Another way to think about the amount of electricity produced by the digester system is provided on the farm website, which states "For every hour that our [digester] system runs, which is every hour of every day, we generate enough electricity in an hour to power an average Wisconsin home for an entire month. If we had to purchase diesel fuel to run our system we would need 1000 gallons of fuel per day"[12]

Economics

After their current PPA with We Energies expires at the end of 2022, the Craves would get about three cents per kWh if they continued to sell the electricity from their generator. "What they [We Energies] did offer is that we can evaluate the opportunity to produce our own power to offset what we use here," said Crave. He continued, "because right now we sell everything we make and buy back. In Wisconsin there are no net metering opportunities [at the farm scale]."

Genset Monitoring

The digesters are "very integral to what we're doing."
J Crave

EnTech Solutions

Manure digester partnership serves multiple farms

EnTech Solutions, Town of Springfield, Wisconsin

A set of dairy manure digesters in the Town of Springfield in Dane County were switched from producing electricity to producing renewable natural gas (RNG). A large group of partners, each bringing their own expertise, worked together to make this change. The RNG is injected into a natural gas pipeline in Madison and sold as a low carbon fuel in the California market to provide clean-burning vehicle fuel.

EnTech Solutions, one of the partners, says, “Overall, the facility reduces emissions by more than 13,500 metric tons of carbon dioxide equivalent per year. This reduction is comparable to removing emissions of nearly 34 million miles driven by passenger vehicles.”

Digester Facts

Manure from 4200 wet cows on 4 farms

3 million-gallon digesters

Phosphorus removal from digester liquid

Digester solids sold to compost company

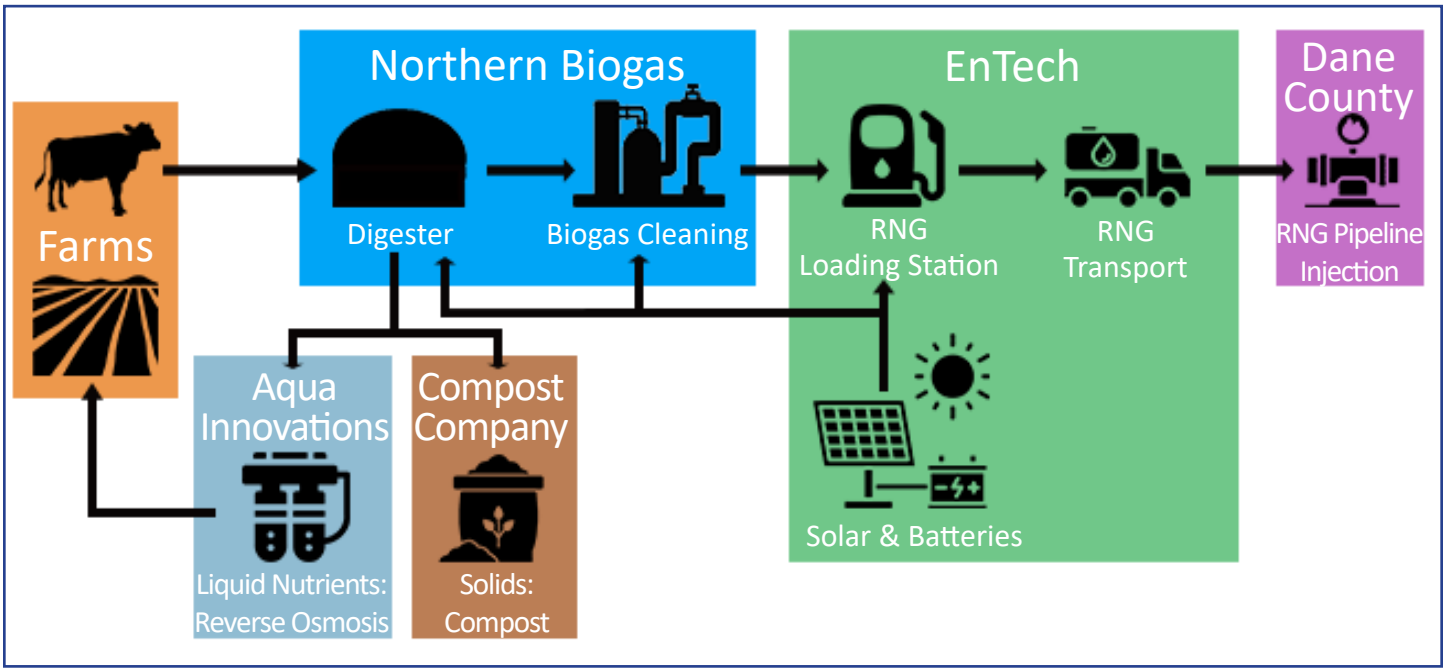
On-site biogas cleaning

RNG production proprietary

2.8 MW photovoltaic panels produce electricity for the facility and grid

Zeigler Dairy Farms across from EnTech Solutions transports manure via pipeline to the digester

RNG Production Process



RNG Production Process[13]

1. Dairy farms supply manure

"The facility currently receives manure from four farms, and is likely to add two more later, according to Scott Romenesko, President of EnTech Solutions." The current farms are providing manure from 4,200 milking cows. More than half of the manure comes from Zeigler Dairy Farms, located across the road from the digester. Manure from the other three dairy farms is trucked approximately 10 miles to the digesters. The farmers are paid per gallon of manure that they provide to the digester. They are not invested in the digester system.

2. Northern Biogas LLC operates digesters and biogas cleaning equipment

Northern Biogas operates and monitors the three one-million-gallon digesters that produce biogas. The digester liquids go to Step 3 for phosphorus removal and are then returned to the dairy farms. The digester solids are sold to Carbon Cycle, a compost company. Northern also operates and monitors the biogas cleaning equipment that removes contaminants from the RNG.

Liquid nutrient loading for delivery to farms

Digestate, digester solids, sold as compost

3. Aqua Innovations operates a reverse osmosis system to remove phosphorus from the digester liquids

Dane County supports phosphorus removal by Aqua Innovations to meet their goal of reducing phosphorus and algae in the Madison chain of lakes. Aqua Innovations uses a reverse osmosis system to concentrate nutrients from the digester liquids. In 2021, over 57,000 pounds of phosphorus were removed and sold to farmers outside the Yahara River watershed. One pound of phosphorus entering a lake or stream can result in up to 500 pounds of algae growth. The digester liquids with reduced phosphorus are trucked back to the dairy farms that provide manure.

Aqua Innovations reverse osmosis system

4. EnTech Solutions operates a microgrid with solar arrays, batteries, inverters, RNG loading station, and truck charging station

EnTech Solutions planned, installed and operates a 2.8 megawatt (MW) microgrid solar array that powers the digester system. The largest onsite solar array consists of fixed, bifacial panels. EnTech also has nearly 500 kilowatt hours (kWh) in battery storage. Extra electricity feeds into the grid. In June 2022 Scott Romenesko said “Right now we’re producing way more electricity than the facility is using with the intention of electric trucks and maybe putting an electric dryer in the solid building and then drying up the [digester] solids, bringing it back to the farmers so they can use that for their bedding.”

In August 2022, EnTech Solutions announced that they plan to partner with Peterbilt Motors and Maki Trucking to use an electric truck to haul the compressed RNG about 20 miles to a pipeline injection port. This truck will be powered by EnTech’s solar arrays.

Battery storage with solar arrays

Future electric truck for transporting RNG to injection site

5. Dane County provides RNG injection port

Dane County provides an injection port on an interstate natural gas pipeline at their landfill. Without access to an injection port, other digesters may not have a way to sell RNG.

6. U.S. Gain purchases and markets RNG

U.S. Gain purchases the RNG and sells it on the California transportation market. California adopted a Low-Carbon Fuel Standard (LCFS) standard in 2007 to reduce their greenhouse gas emissions from transportation by 10% by 2020.

In the future EnTech plans to add manure from another dairy farm or two, add a fourth digester, haul the RNG to the injection port with an electric truck, and consider a few different options to increase use of electricity produced onsite.

EnTech Solutions Middleton digester facility, Town of Springfield, Wisconsin

Economics and Policy

Economic returns for digesters depend highly on the base electricity or RNG price, plus policies for premium rates, financial supports from government agencies and other organizations, and sales of the byproducts of biogas generation.[14] Changes to Wisconsin's Renewable Portfolio Standards have negatively impacted the profitability of digesters producing electricity in Wisconsin. Many dairy digester owners initially burned their biogas in generators to produce electricity and heat. They sold the electricity through Purchase Power Agreements (PPAs) with their utilities that paid within a range of nine to sixteen cents per kilowatt hour (kWh). Utilities were paying these prices for renewable energy to meet their Renewable Portfolio Standards that required a certain percentage of their electricity to come from renewable sources.[15]

When these PPAs expired, prices paid for electricity declined sharply to 2-3 cents per kilowatt hour, due in part to 2011 Act 34 which allowed utilities in Wisconsin to meet their Renewable Portfolio Standard with electricity from large-scale hydropower put in service in Manitoba, Canada in 2004 or later. In addition, utility variable costs of electricity generation from natural gas have decreased significantly from 2005-2017.[16]

Some dairy digesters are also shutting down in the state of New York due to low prices paid for electricity. In contrast, Vermont set the rate for electricity from digesters at 14 cents per kWh in 2011, plus consumers can voluntarily pay an extra 4 cents per kWh. These electricity prices are keeping Vermont dairy digesters producing electricity.[17]

Net metering also impacts the finances of digester operations. Low net metering limits at many utilities, as well as reductions in net metering buyback rates have reduced profitability of digesters producing electricity. Wisconsin utilities allow net metering up to 20 kW, 100 kW or 300 kW.[18] In comparison, net metering limits are much higher in surrounding states, which allows digesters to be more profitable. Illinois allows net metering to 5,000 kW, while Minnesota, allows net metering up to 1,000 kW.[19] Net metering eligibility policies and rates have made it more difficult to maintain the profitability of existing digesters or support investment in new systems, particularly for customers of utilities with lower eligibility thresholds and buyback rate values.

Net Metering means a customer is billed for the difference between the energy it consumes and the energy it produces during a set time frame. With net metering,if a customer generates more electricity than they use, the customer is paid the retail rate for electricity generated. For example, if a utility charged 12 cents per kWh for electricity and a customer generated 20,000 kWh and used 10,000 kWh, they would be paid for the difference, 10,000 kWh.

10,000 x $0.12 = $1200 payment

In contrast, without net metering a utility could charge 12 cents per kWh for electricity used by a customer, and pay only 4 cents per kWh for energy generated by the customer. Without net metering a customer with the same electricity generation and use as above would pay more because they are paid less for the electricity they generate.

(20,000 x $0.04) - (10,000 x $0.12) =
$800 - $1200 = $400 charge

Figure 2: Net metering description and example

Due to these policies, selling electricity from many digesters became unprofitable in Wisconsin. As a result, digester owners are looking for options to make digesters profitable again and maintain the valuable digester coproducts that benefit their farms and communities. Options include:

- continue to use a generator to produce electricity and heat from the biogas,
- install new biogas cleaning equipment to produce RNG, compress it, in some cases truck it, and inject it into a natural gas pipeline if available,
- flare the biogas, or
- stop use of the digester.

Economic Incentives for RNG

Federal and state programs for renewable fuels provide payments for renewable energy credits to convert biogas into RNG. The federal Renewable Fuels Standard (RFS) program provides market-based payments for renewable fuels, including RNG. In addition, the states of California, Oregon and Washington have Low-Carbon Fuel Standard (LCFS) incentive programs that provide additional credits for biofuels, including RNG. Payments come from these western states if the fuel, regardless of origin, is conveyed (via pipeline or other means) and used as a transportation fuel in one of the states with a LCFS program.[20]

A second market developing for RNG is the voluntary market, made up of companies and other organizations that have committed to lowering their emissions, and are investing in large RNG projects.[21]

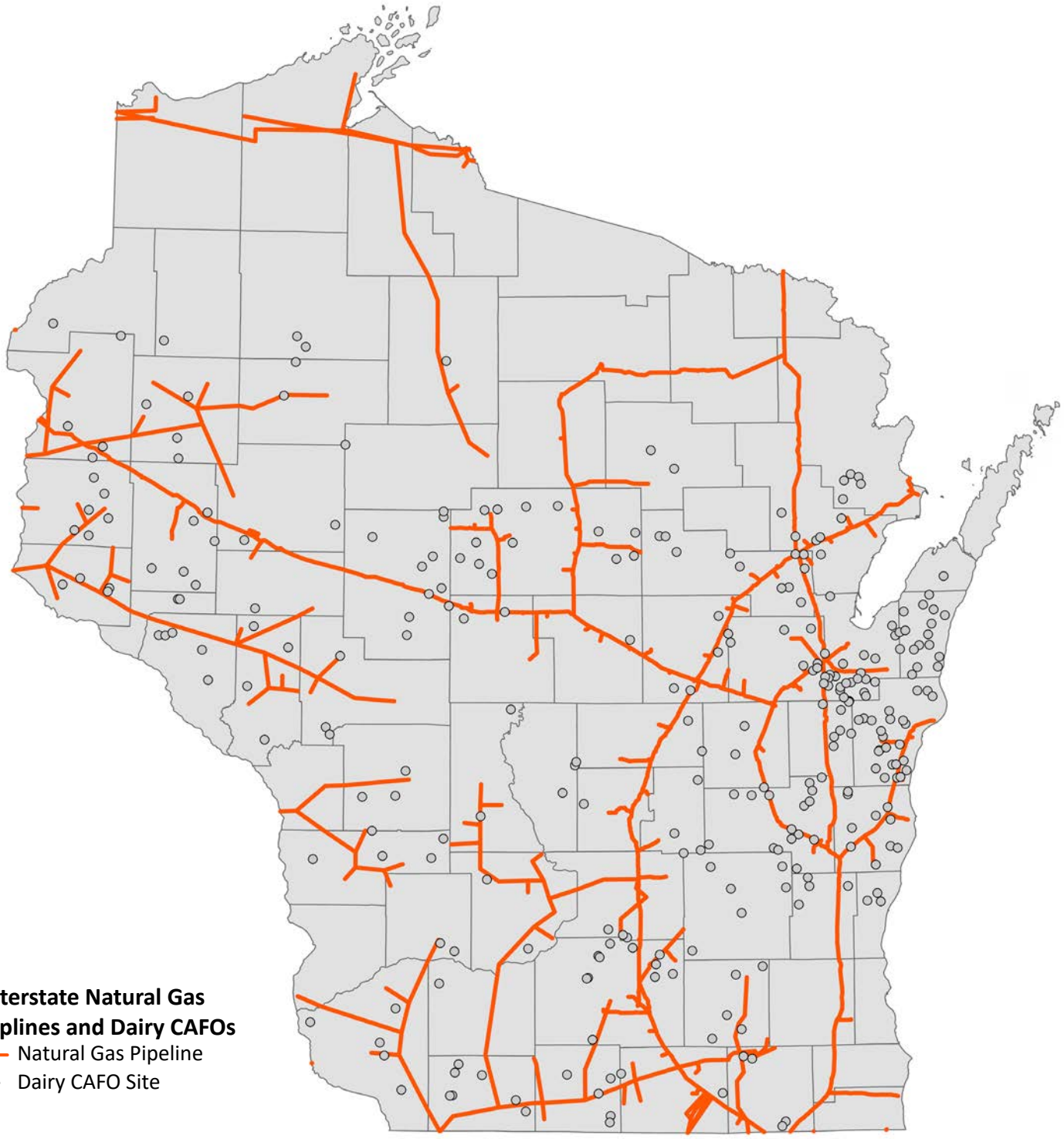
Digesters that produce RNG typically inject it into an interstate natural gas pipeline to get the federal RFS credits and the LCFS credits from states or credits from the voluntary market of companies and organizations that have committed to lowering their emissions.

Map 3 shows the locations of Wisconsin's 323 dairy CAFOs and the interstate natural gas pipelines. For 275 dairy CAFOs the shortest distance, as a crow flies, to an interstate pipeline is less than 10 miles. For 318 dairy CAFOs the distance to a pipeline is less than 20 miles. The only CAFOs not within 20 miles of a pipeline are four in Kewaunee County and one in Door County. However, it is important to note that we do not have data on the location of the injection ports on the interstate natural gas pipelines. Therefore, a CAFO that is 20 miles from an interstate pipeline may be a much farther distance from an injection port where RNG could be injected into the pipeline. As of September 2022, we do not know how many dairy CAFOs in Wisconsin are located within a feasible distance to truck the RNG from the dairy to an injection port on an interstate natural gas pipeline.

See Appendix A for additional maps showing dairy CAFO proximity to interstate natural gas pipelines.

Potential for Adding Injection Ports in Interstate Natural Gas Pipelines

WEC Energy, the state's largest energy utility, estimates that the cost to install an injection port is between $2 million and $5 million. In July 2022, WEC Energy received approval from the Wisconsin Public Service Commission for a pilot program to install injection ports for 15 customers – either farms or third-party digesters.[22] WEC Energy includes the natural gas service territories of Wisconsin Electric Power Company, Wisconsin Gas, and Wisconsin Public Service located in southeast, northeast, and central Wisconsin.[23]



Map 3: Wisconsin dairy CAFOs and interstate natural gas pipelines[9,24,25]

Appendix A: Maps

Dairy (323 CAFOs)

Turkey (17 CAFOs)

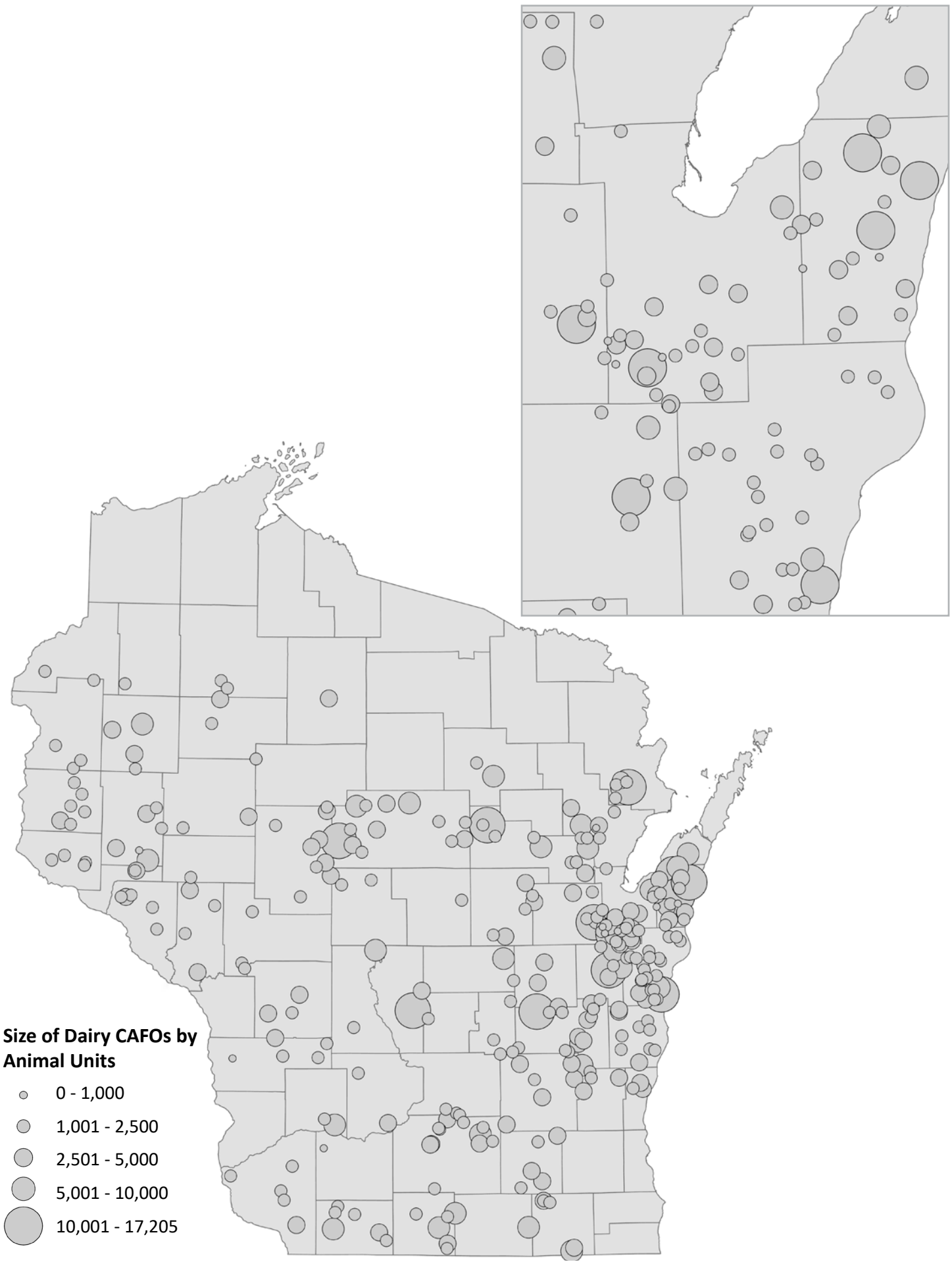
Swine (13 CAFOs)

Chicken (7 CAFOs)

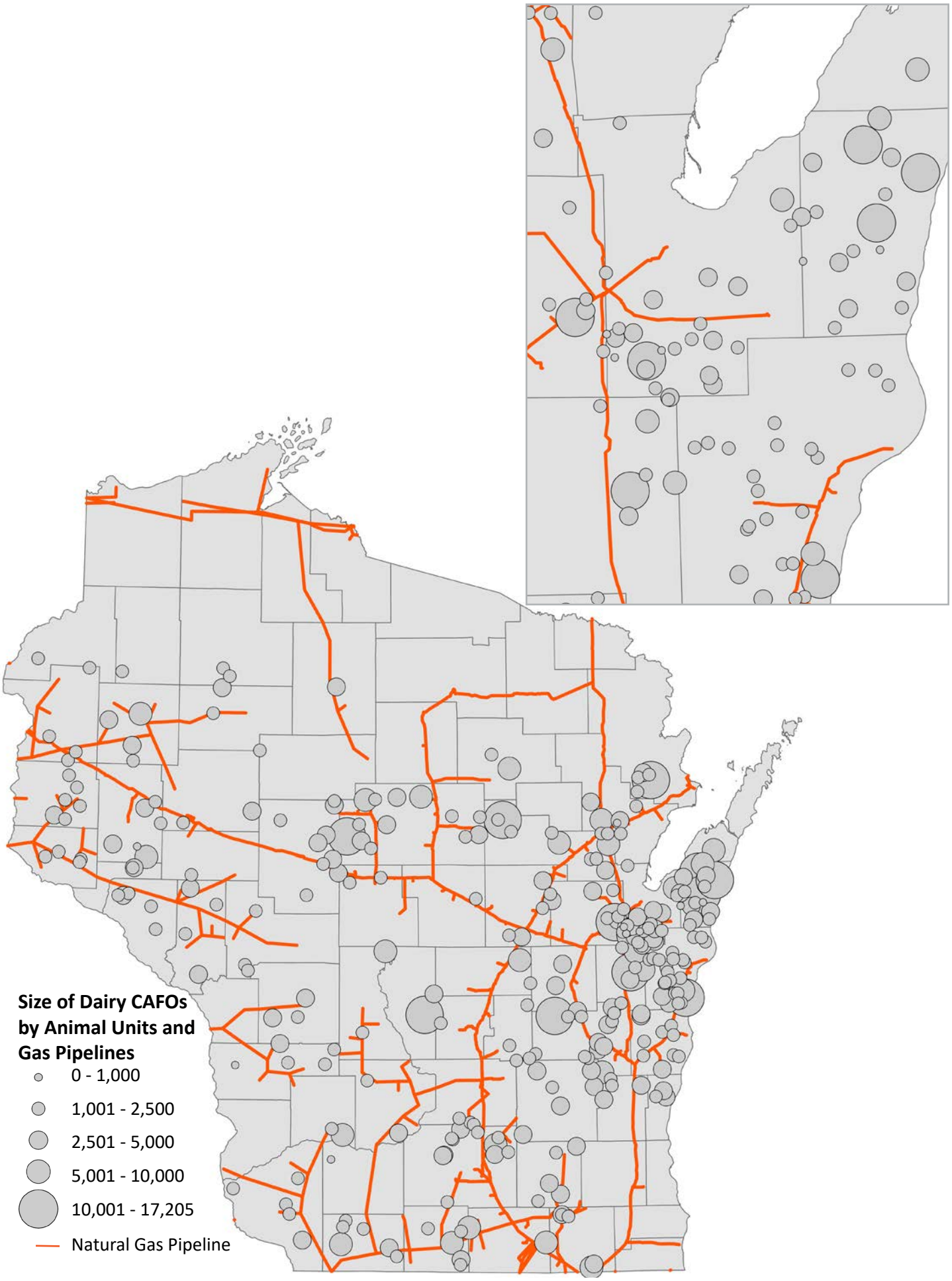
Beef (10 CAFOs)

Duck (1 CAFOs)

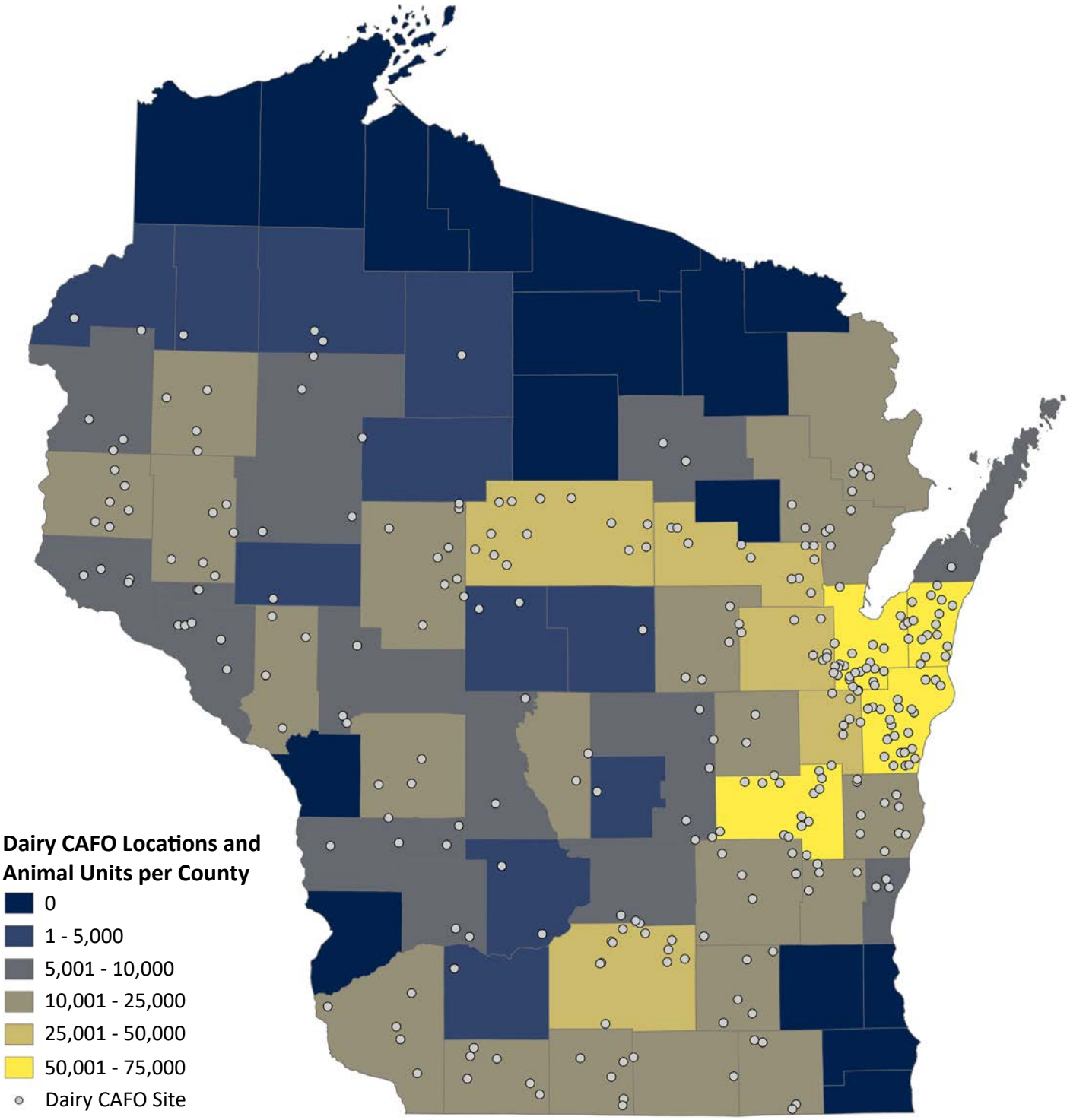
Map 4: Number of CAFOs by individual animal type[9,24]



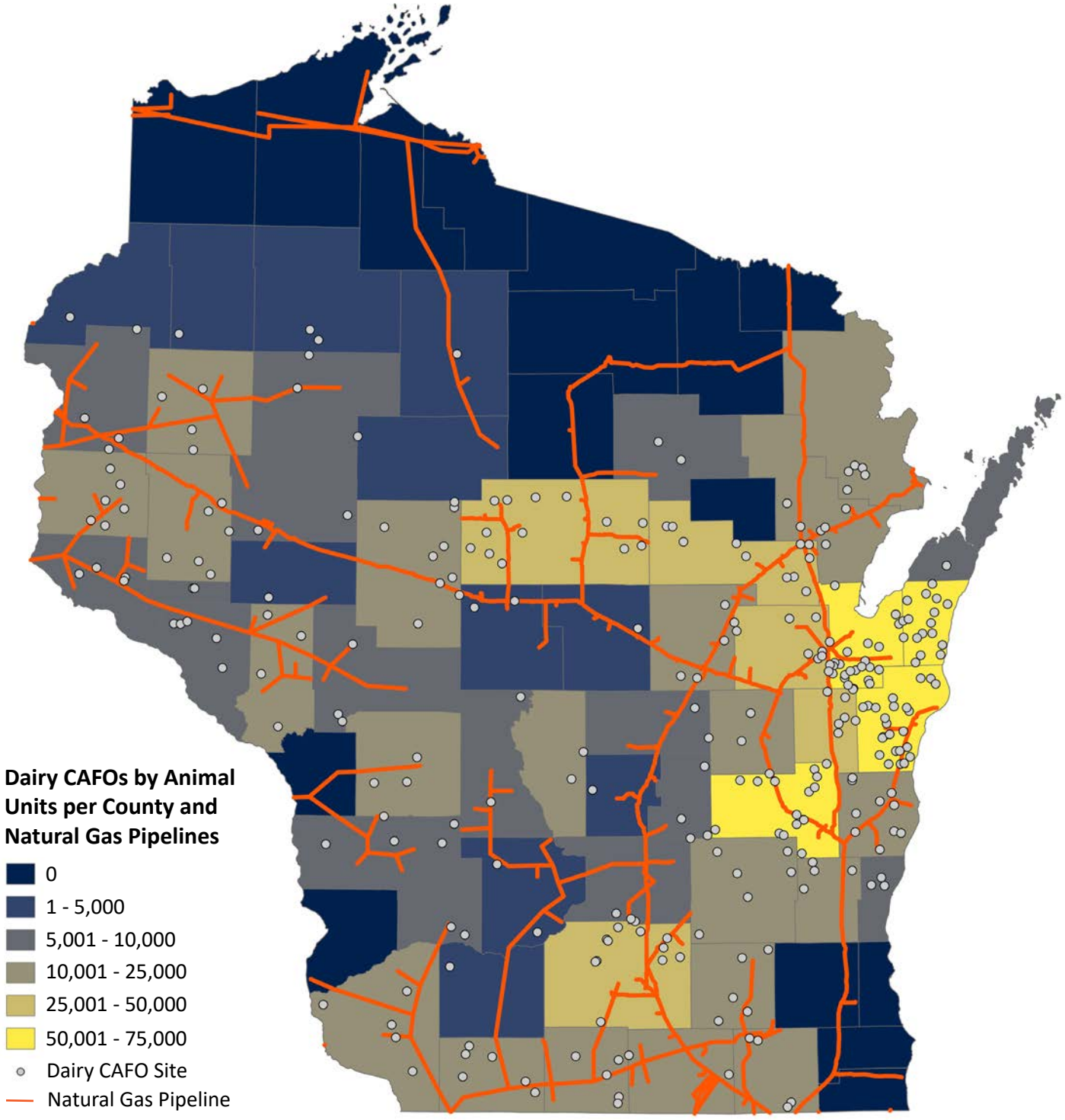
Map 5: Size of dairy CAFOs by animal units[9, 24]



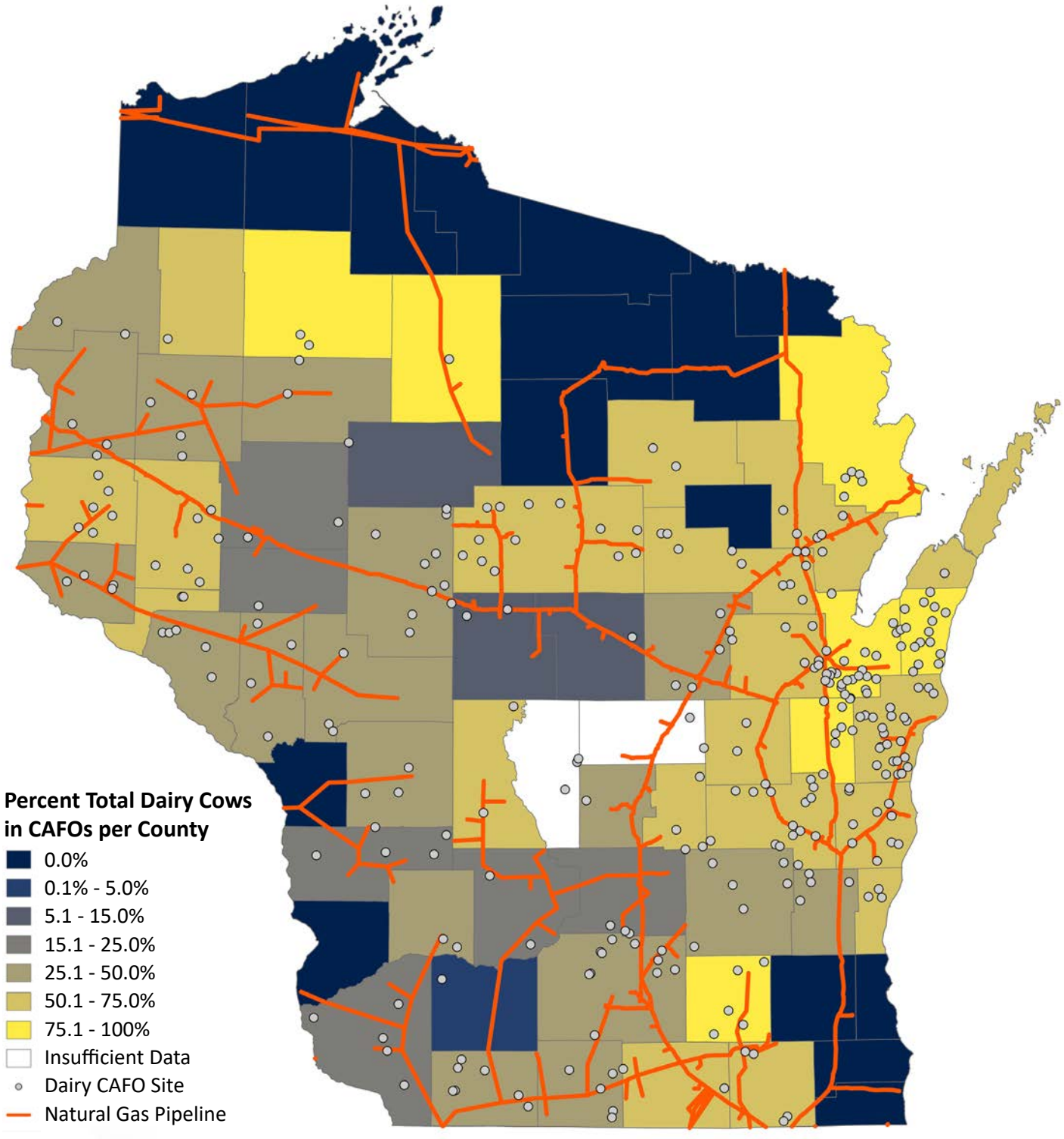
Map 6: Size of dairy CAFOs by animal units and interstate natural gas pipelines[9,24,25]



Map 7: Dairy CAFO locations and animal units per county[9,24]



Map 8: Dairy CAFOs by animal units per county and interstate natural gas pipelines[9,24,25]



Map 9: Percent of total dairy cows in CAFOs per county and interstate natural gas pipelines[9,24,25]

This map shows the percentage of dairy cows in CAFOs compared to the total number of dairy cows in each county. In following the trends from the number of CAFOs per county, the highest percentage of dairy cows in CAFOs is located in Brown (100%), Jefferson (100%), and Marinette (97.8%) counties. Some counties with over 75% of their total dairy cows in CAFOs are more urban (Brown and Jefferson) while others are rural (Marinette, Sawyer and Price). In contrast, nine counties (dark blue) hold 0% of their dairy cows in CAFOs.

Due to a lack of publicly published information, there was insufficient data to calculate this percentage for Adams and Waushara counties.

Appendix B: Digester Impacts on Nutrients in Manure

Digesters change the form of the nitrogen and phosphorus in the manure. As a result the digested manure is more versatile than raw manure and can be applied directly to hayfields and some types of recently planted cover crops.

Digesters do not reduce the amount of nitrogen or phosphorus in manure.

The total amount of nitrogen going into the digester will equal the total nitrogen leaving the digester. Digestion often shifts the form of the nitrogen to more ammonium. When digested manure is field applied, much of the ammonium will be released as a gas (ammonia) unless it is incorporated into the soil.[26] Because nitrate is water soluble, it can move easily into the groundwater, which is used for drinking water. The Wisconsin Department of Health Services describes how high levels of nitrate in drinking water can affect everyone's health. When incorporated, the ammonium is converted to nitrate, the nitrogen form most readily taken up by plants. When digested manure is field applied, much of the ammonium will be released as a gas (ammonia) unless it is incorporated into the soil. When incorporated, the ammonium is converted to nitrate, the nitrogen form most readily taken up by plants.[26] Because nitrate is water soluble, it can move easily into the groundwater, which is used for drinking water. The Wisconsin Department of Health Services describes how high levels of nitrate in drinking water can affect everyone's health.[27]

Similarly, the microorganisms in the digester do not consume phosphorus. Some of the phosphorus does settle out into the solids portion of the digestate.[26]

See the Crave Brothers Farm story for a discussion of how their digester helps with nutrient management.

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