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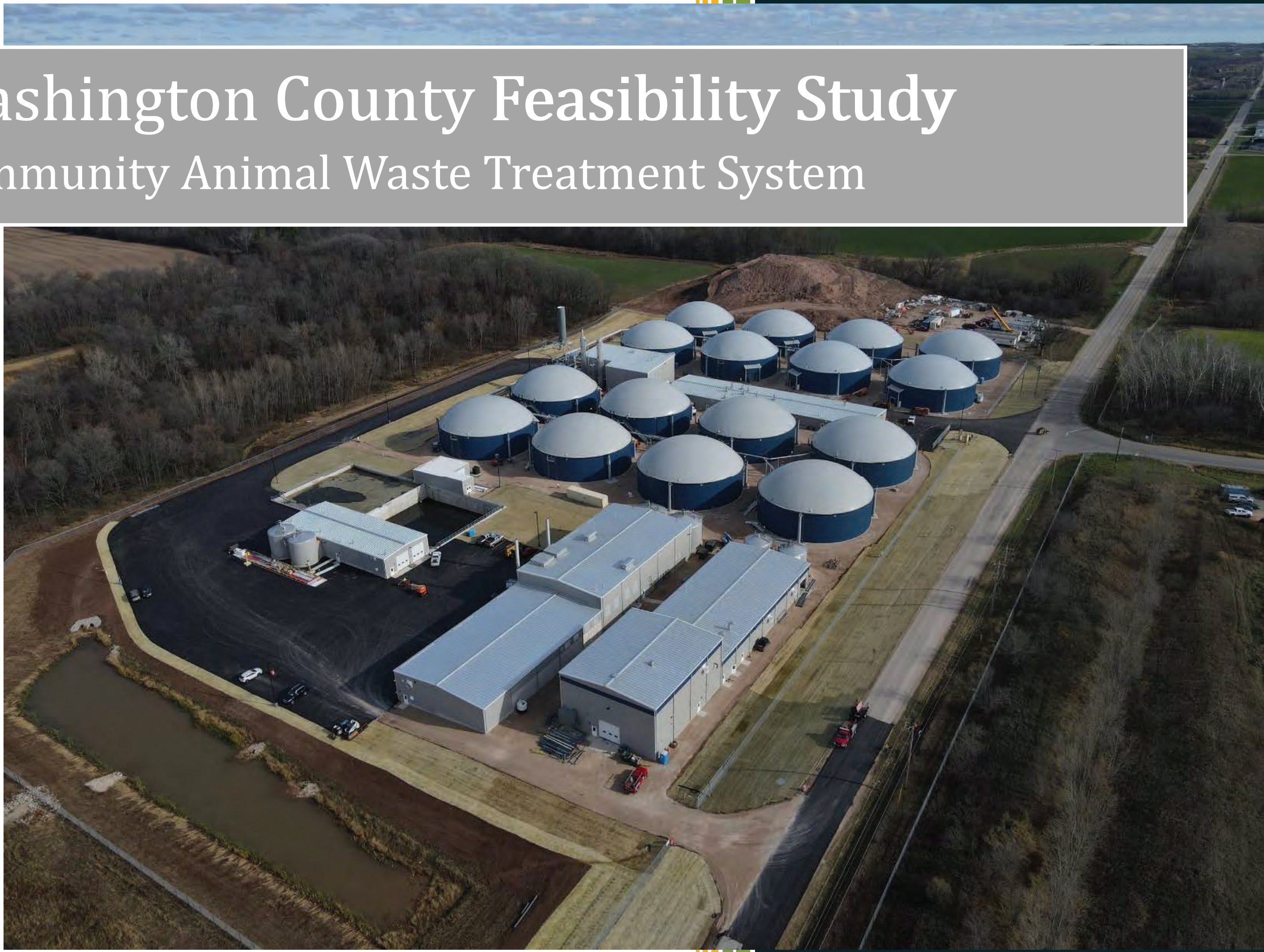
Washington County Feasibility Study

Community Animal Waste Treatment System



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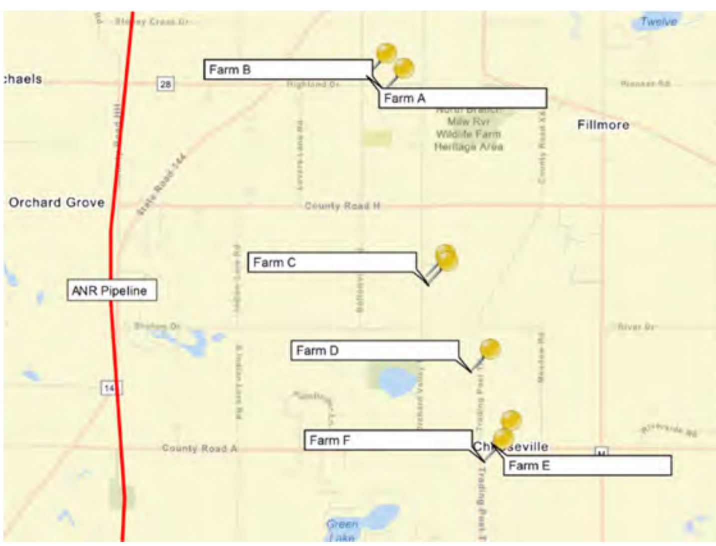
1.0 Executive Summary

The purpose of the study is to explore the feasibility of a community-based manure treatment system in Washington County for the group of farms identified in the RFP.

Washington County identified a cluster of farms for a potential manure treatment facility in eastern Washington County. These farms are in the Milwaukee River Watershed in which numerous waterways are listed as 303 (d) impaired waterways and are subject to a total maximum daily load (TMDL). In the project area, the main pollutant is phosphorus and agriculture is one of the non-point contributors of phosphorus to the waterways. One way to positively impact the potential for phosphorus entering the waterways is by changing the volume and the timing of manure applications.

This feasibility study evaluates technology for anaerobic digestion and manure treatment systems and then evaluates the business model given current market economics. From a technical perspective, it is possible to create a project that reduces the manure volume stored and applied in half while also segregating the phosphorus from the nitrogen and potassium. Anaerobic digestion is a pre-treatment step that can provide a revenue source to offset the operating costs of the manure treatment system.



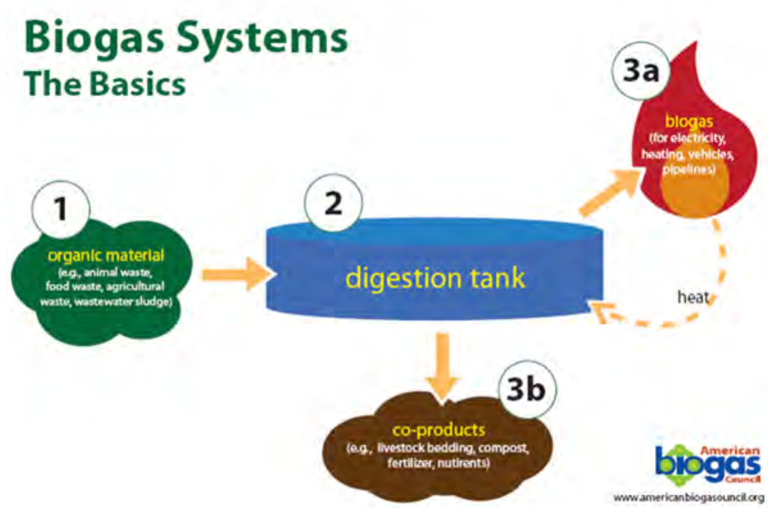
In order to create a financially feasible project, the biogas will need to be upgraded to renewable natural gas (RNG) and injected into the natural gas transmission system in order to sell the RNG into the markets paying a premium for the renewable gas.

Next steps for the project include securing an RNG off-take agreement that meets the financial feasibility of the project, contracting with the participating farms for their manure, and securing a site for the proposed facility.

2.0 Project Description

The purpose of the Washington County Study is to explore the feasibility and sustainability of the construction of a waste treatment facility designed primarily to receive manures from nearby dairy farms and harvest marketable byproducts to sell or return to farmers.

Our findings indicated that integrating anaerobic digestion (AD), nutrient concentration (NC) systems, organic fertilizer production systems, and renewable natural gas (RNG) can accomplish the goals of improving the economics of manure handling while having positive effects on the environment.



AD is a waste treatment process which manages and treats animal wastes by reducing pathogens and odor prior to introduction on farm lands. The methane generated is used to create renewable power (RP) or renewable natural gas (RNG).

When discussing manure management with dairy farms, the main concerns are:

- Volume of manure
- Nutrient management limitations
- Hauling costs/distances

On multi-generational farms, manure has been applied near the main farm for years, causing a buildup of nutrients in the soils. As the farm grows and is required to follow a nutrient management plan that limits the amount of manure that can be applied due to the nutrient levels of the soils, they need to haul the manure further from the main farm, increasing their operating costs. The manure is rich in nitrogen, phosphorus, potassium and other micro nutrients, providing fertilizer for crop production. The application rates run from 7,000-15,000 gallons per acre depending on their nutrient management plans and soil hydraulic loading rates. Sometimes the over application of nutrients happens due to the expense of hauling further away from the livestock production facility causing a buildup of nutrients in the soils.

The objectives of installing a nutrient concentration (NC) system are to improve the economic efficiencies of manure handling, improve flexibility of the timing of manure application, and reduce the adverse environmental impact of nutrient loading to ground and surface waters by making the redistribution of nutrients economically feasible.

We evaluated NC systems that are technically capable of successfully decreasing the volume of land applied manure by 30-70%. Stated simply, the NC system "dewaters or removes water" from the manure. Removing over half of the volume as clean water allows the strategic management of nutrients because of the improved economic feasibility of hauling further distances. The volume reduction provides more flexibility in the timing of manure field applications. The dairies will have an increased ability to apply manure during low risk time periods and avoid applications during in-climactic conditions. The NC system also separates the phosphorus from the nitrogen and potassium since the majority of the phosphorus goes with the solids and the majority of the nitrogen and potassium go with the liquids. This allows for the reallocation of the nutrients from where it is causing water quality issues and economically redistributes it to land that is in need of nutrients for crop production. The nitrogen and potassium can be applied at more precise times when the crop needs the nutrients (i.e.: split applications or prior to planting) instead of applying manure when the crops are not able to utilize the nutrients such as fall applications. Operating these systems in series will create an overall volume reduction of up to 70%. Additional benefits to reducing the manure volume include less wear and tear on town and county roads as the volume needed to apply nutrients has been reduced. With the reduced volume, the manure can be stored for longer periods of time in existing lagoons ensuring the application of the nutrients takes place when the crops can utilize them and avoiding the time of the year that has the highest likelihood of a run-off event. The digestion process will also reduce the odor associated with manure storage and land application.

Additional options for nutrient management are also emerging on the market. One company offers a solution that recovers aqueous ammonia from the manure stream, and the remaining nutrients are dried and pelleted. Their business model removes all the nutrients from the farm except for the separated fiber. Another option utilizes pyrolysis to produce a biochar from the solids portion of the manure stream. This business model removes a portion of the phosphorus and organic nitrogen from the manure nutrients as it is converted into a biochar and sold off the farm.

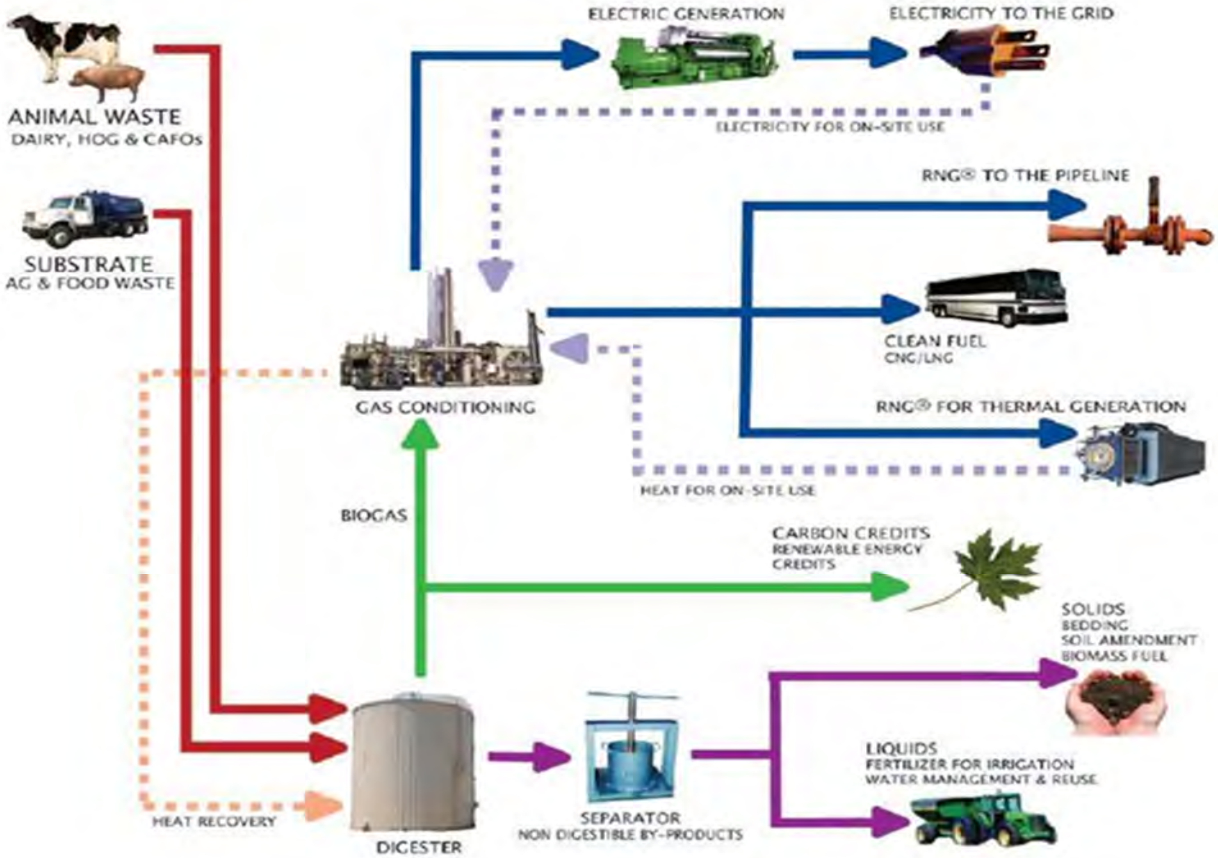


Figure 2.1: Typical Biogas Plant Process Flow Diagram

3.0 Nutrient Management Analysis

3.1 Nutrient Balance Overview

The feasibility report focuses on technology and the feasibility of various approaches to manure management. The core of the issue in Washington County revolves around agronomy issues as it relates to manure management and the technology components are simply the tools to help better manage this resource. The 4R's of the nutrient stewardship concept involves applying the right fertilizer source at the right rate, at the right time, and in the right place[1]. By utilizing the various manure processing technologies currently available, the farms would have more tools to help them optimize their application to the 4R's while protecting ground and surface waters.

In order to estimate the nutrient content of the various products produced by the advanced separation processes, we developed a model that would track the nitrogen, phosphorus, and potassium through the steps of separation. This model was based on our experience in the industry and input from various equipment suppliers. We started the analysis by assuming the nutrient content of the manure prior to separation has a total nitrogen content of 24 lbs./1,000 gallons, a P_2O_5 content of 8 lbs./1,000 gallons, and a K_2O content of 21 lbs./1,000 gallons and a total dry matter content of 4.1-11%.[2] After meeting with the farms in the identified cluster, there are a total of 5,920 equivalent milk cows. Based on their milk production information and correlating their milk production to manure production, they average about 27.5 gallons of manure per cow equivalent per day including parlor water. This creates 59 million gallons of manure annually which includes 1,425,000 lbs. of nitrogen, 475,000 lbs. of P_2O_5, and 1,247,000 lbs. of K_2O. The first stage of separation creates the stackable separated solids. The projected nutrient profile of the separated solids is 8 lbs./ton of nitrogen, 20 lbs./ton of P_2O_5, and 7 lbs./ton of K_2O. It is estimated this facility will produce 12,000-18,000 wet tons of separated solids annually. The facility is projected to produce about 14 million gallons annually of the UF concentrate, 14 million gallons annually of the RO concentrate, and the balance being clean water. The UF concentrate has a projected nutrient profile of 30 lbs./1,000 gallons of nitrogen, 22 lbs./ 1,000 gallons of P_2O_5, and 18 lbs./ 1,000 gallons of K_2O, and the RO concentrate has a projected nutrient profile of 40 lbs./1,000 gallons of nitrogen, 1 lb./ 1,000 gallons of P_2O_5, and 55 lbs./ 1,000 gallons of K_2O.

Manure has significant value as a crop fertilizer, but unlike commercial fertilizers, the nitrogen-phosphorus-potassium ratios are a function of the manure and the ratios typically don't match up with the crop uptake needs. In many cases, application to meet the nitrogen needs of a crop will lead to the over application of phosphorus or application to the phosphorus needs will require a commercial nitrogen fertilizer application in addition to the manure. These issues create challenges when trying to adhere to the principals of the right rate and the right place.

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[1] The Fertilizer Institute. http://www.nutrientstewardship.com/4rs/4r-principles.

[2] Laboski, Carrie A.M., Peters, John B. *Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin.* Page 75. University of Wisconsin – Extension. A2809.

Another challenge with manure as a fertilizer is that it is 90-95% water. This leads to significant volume challenges in trying to distribute this volume across the acres in short windows of time. Due to the solids in manure and form of the nutrients, application typically occurs in the spring of the year prior to planting and the fall following harvest to avoid spreading manure on growing crops other than fresh cut alfalfa fields. To meet the fertilization needs of the crop, 7,000-15,000 gallons per acre are applied. Depending on the soil saturation and soil temperature, this dilute volume has the potential to make the nutrients more mobile than commercial fertilizers. It also stresses the local roads with significant amounts of truck traffic. Assuming half the manure in the cluster has to be trucked to the desired fields, that would put over 5,400 semi-trucks on the roads annually.

3.2 Anaerobic Digestion

The anaerobic digestion step does not reduce or segregate any of the nutrients that were initially introduced into the system. The value of anaerobic digestion is as a pre-treatment step for advanced separation by converting a portion of the organic nitrogen to an inorganic form (making the nitrogen more available to the plants), homogenizing the manure by mixing it for an extended period of time, breaking down the volatile organics which increases the efficiency of membrane systems and reduces cleaning cycles, reducing the pathogens in the manure, and providing a constant elevated temperature which increases the efficiency of separation of the suspended solids. It also significantly reduces the odor of manure by breaking down the volatile organics and creating biogas.

3.3 Coarse Solids Separation

The first stage in the separation process removes the coarse suspended solids from the manure stream. These coarse solids are typically separated through a mechanical screw press and produce a stackable product with about 70% moisture. This product contains about 25% of the phosphorus from the manure stream and is the first step in starting to segregate the phosphorus from the nitrogen and potassium. Options for use of the coarse separated solids are typically cow bedding, land application, or composting.

The challenges with using the 70% moisture solids as bedding in barns with deep bedded stalls is it has a tendency to create higher somatic cell counts than sand or sawdust. The advantages of using the solids as bedding is that it recycles a product on the farm and no longer requires the farm to purchase their bedding. It is also easier on the manure handling equipment and lagoons than sand.

With a projected nutrient value of 2.0%-0.4%-0.6%, it has a relatively low value as a fertilizer for land application. The value of this product for land application is the organic matter and micronutrients it provides to the soil. The challenges with this product is that it can typically only be applied in the spring and fall and needs to be stored extended periods of time.

For this project, it was assumed that a natural gas fired drying system would be installed to dry the coarse fiber from 70% moisture to about 55% moisture. The highest value use for the dried coarse solids is as cow bedding. At 50-60% moisture, this product overcomes most of the herd health issues associated with the 70% moisture bedding, and with the heat requirements needed to reduce the moisture, there is an additional pathogen kill in the fiber which reduces the potential issues related to biosecurity. At 55% moisture, it also opens up this product to be shipped to horticultural wholesalers for incorporation into their soil amendment products as an alternative to peat moss. By reducing the moisture content, it cuts the weight of the product by about 60%, improving the economics of trucking it to these locations. This provides a secondary market for this product in the event there are more coarse solids produced than can be used as bedding.

3.4 Fine Solids Separation

Fine solids separation is the second step in the process. By removing the fine solids from the manure stream, up to 95% of the phosphorus contained in the manure stream can be segregated from the nitrogen and potassium. This step creates a phosphorus rich cake product and a nitrogen and potassium liquid product typically referred to as "tea water". If the farm is set up for irrigation, the tea water can be run through the irrigation system to add nitrogen and potassium to the crops as they are needed. This step is also used to reduce the amount of suspended solids in the manure stream to below 1% if the goal is to separate the clean water from the nutrient rich liquid. Fine solids separation systems often use polymers and coagulants to bind together the finest particles into a larger particle to allow it to be separated. Options for use of the fine separated solids are land application, blend back with the nutrient rich water prior to land application, or drying and selling as a horticultural product.

The fine solids can come out of the process at about 75-80% moisture as a stackable cake or can be produced as a 80-85% moisture slurry. Again, this product has a relatively low fertilizer value of 0.5%-0.8%-0.3% but contains about 70% of the phosphorus in the manure stream. The challenge with utilizing the cake product for land application is the storage requirements. The system produces a significant amount of cake on a daily basis which takes up a considerable amount of space when piled and stored. It can also create leachate problems if not stored under a roof. If the farm wants to keep this product for land application, it is easier to handle as a slurry and utilize a liquid storage structure to hold the slurry between land application intervals. If the farm has multiple lagoons, one could be used to store the liquids with the fine solids and this product could be applied on fields with a phosphorus need, and the concentrated nutrient liquid that contains primarily nitrogen and potassium could be stored separately and applied to fields that don't require phosphorus.

The liquids produced from this step or "tea water" can be stored for land application or further processed to separate a majority of the water from the nutrients. If a farm has the infrastructure to irrigate the tea water on acres close to the farm, this is a cost-effective way to apply both the volume and nutrients at times when the crops can utilize them. The tea water represents about 75-80% of the original manure volume and primarily contains the nitrogen and potassium. The majority of the nitrogen in the tea water is also in an inorganic form which allows the crops to utilize it more readily. Additional information regarding manure irrigation can be obtained through the Wisconsin Manure Irrigation Workgroup Report "Considerations for the Use of Manure Irrigation Practices"[3]. Local ordinances regarding the irrigation of manure would also have to be reviewed to ensure that it is permissible.

One of the drawbacks to irrigating the tea water is the infrastructure required for irrigation. Most farms in the cluster do not have irrigation equipment in place. Also, many fields are too small or have too much slope for irrigation.

Finally, another option for the tea water is to further process it to separate the water from the nutrient stream. This is typically done through multiple filtration steps such as ultrafiltration and reverse osmosis.

3.5 Suspended Solids Removal

The third stage of advanced separation is the removal of the very fine suspended solids from the manure stream. This step is typically utilized as a preparatory step prior to reverse osmosis when the goal is to create clean water. There are multiple technologies that can perform this function such as bag filters, sand filters, and ultrafiltration (UF). These systems are designed to remove particles 0.1 to 0.001 micron in size.

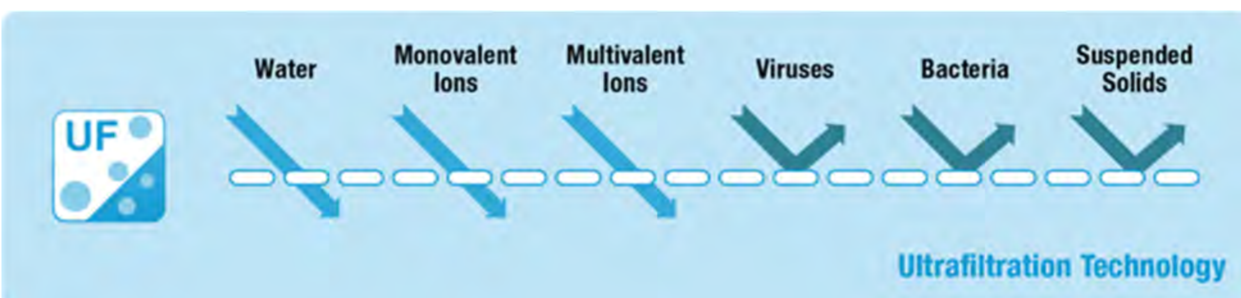


Figure 3.5.1: Ultrafiltration Technology Courtesy of Aqua Innovations.

The suspended solids removal process rejects the remaining suspended solids from the tea water. This product can be recycled back to the start of the fine solids separation process or put directly into storage for land application. If a mechanical separation system is utilized for fine solids separation, it would be recommended to put this product directly into storage. If a polymer based system is utilized

[3] University of Wisconsin – Extension. https://fyi.uwex.edu/manureirrigation/workgroup/

for fine solids separation, this product can be recycled back to the start of that process to maximize the percentage of clean water that can be produced by the system. Once the suspended solids are removed from the liquid stream, it is ready to be processed through a reverse osmosis system to remove the dissolved solids from the water.

3.6 Dissolved Solids Removal

The final stage in advanced separation is the separation of the dissolved solids from the clean water. This is typically done with a reverse osmosis (RO) system. An RO system uses membranes to filter out salts and particles down to 0.1 nanometers. They are typically designed to provide 70-80% clean water recovery of the incoming stream. This yields 30-65% clean water of the original manure stream sent to the first separation stage.

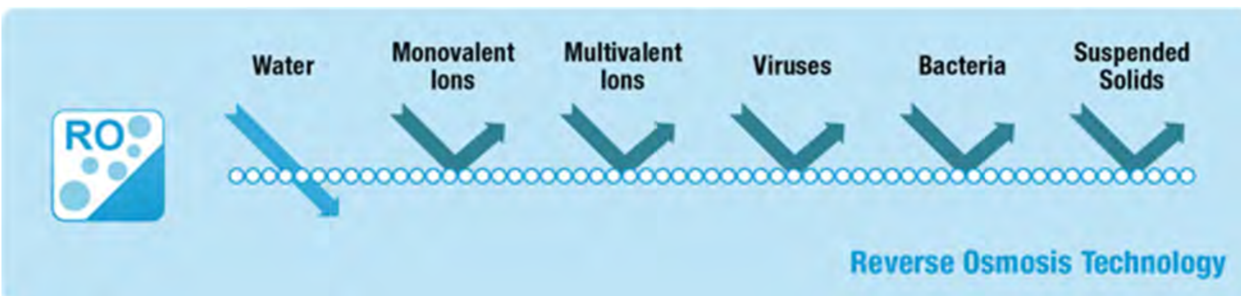


Figure 3.6.1: Reverse Osmosis Technology Courtesy of Aqua Innovations.

The RO system uses a high-pressure pump on the feed side of the membrane system. As the feed material is pressurized on the outside of the membranes, the clean water is able flow to the center of the membrane tube and out of the system. The clean water is referred to as the permeate. The remaining dissolved solids that don't pass through the membranes are rejected from the system as the concentrate. The concentrate contains the soluble nitrogen and potassium. Most suppliers also inject an acid prior to or in one of the stages of the RO to convert the ammonia-nitrogen to a more stable ammonium-nitrogen. By converting the ammonia-nitrogen to ammonium-nitrogen, it is less likely to volatize in storage or after land application, making a higher percentage of the nitrogen plant available.

The concentrate typically contains 2-3 times the concentration of nitrogen and potassium as the original manure stream and is readily available to the crop. If the product is hauled and applied through traditional application methods, it can be applied at significantly lower volumes per acre to achieve the desired fertilization levels. It can also be applied to meet the nitrogen needs of the crop since it does not contain phosphorus. This also significantly reduces the truck traffic utilized for manure application. By concentrating the nutrients and reducing the volume, the concentrate can be spring applied or applied through the growing season and eliminate the need for fall application.

The remaining clean water generated by the process could be re-used by the farming operations, irrigated on acres close to the farm, or discharged to surface waters. Since the water is a valuable resource, re-using it on farm or irrigating it would be preferred options. Irrigating the clean water avoids many of the concerns associated with manure irrigation since it is almost nutrient free, mineral free, and pathogen free.

Advanced separation systems help improve the ability to achieve the 4R's of agronomy by segregating the phosphorus from the nitrogen and potassium, separating the solids from the liquids, and reducing the volume of manure that needs to be applied. These help by applying the nutrients in the correct rate to the correct place at the correct time to maximize nutrient uptake by the crops. Combining these practices can also eliminate the need for fall application of manure.

Reduced application rates and loads per acre will also reduce soil compaction on the fields which will lead to increased yields. Also, by irrigating the water on the growing crops, yields will be increased and the risk profile for crop insurance will be reduced. By increasing yields, more nutrients are consumed by the crops. All these factors help to reduce the ability of the nutrients to find their way to surface and ground water sources.

4.0 Technology Review

4.1 Anaerobic Digestion

An anaerobic digester is a waste treatment technology which manages and treats animal wastes prior to introduction on farm lands. Biogas produced by the system can be utilized as a source of renewable energy.

This technology is proven and well understood among various livestock and human waste handling systems.

- Over 7,500 biogas plants in Germany alone *(source: German Biogas Association)*
- 16,000 Wastewater Treatment Plants in the U.S. and 3,500 of these employ anaerobic digestion *(source: U.S. Department of Energy).*
- 416 ag based operational systems in the U.S. *(source: EPA AgSTAR Database)*
- 45 systems in the state of WI located on dairy farms *(source: EPA AgSTAR Database)*
- 22 of these systems produce electricity and 19 produce natural gas *(source: EPA AgSTAR Database)*

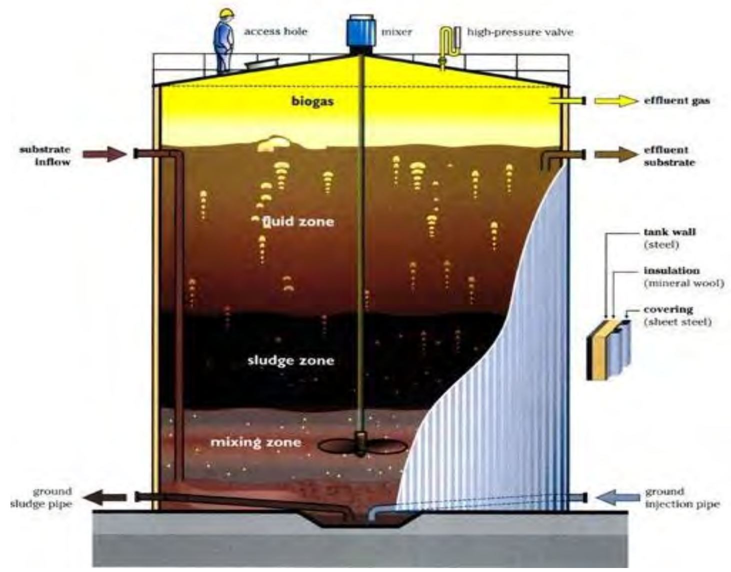
The process utilizes bacteria in the absence of oxygen to break down organic materials. As organic material breaks down, it generates biogas with 55-65% methane content. Under controlled conditions, anaerobic digestion is a holistic treatment solution that stabilizes the nutrient stream. In addition, it also produces a significant amount of energy in the form of biogas, while controlling odors, reducing pathogens, minimizing environmental impact from waste emissions, and maximizing fertilizer nutrient and water recovery.

Controlled anaerobic digestion requires an airtight chamber called a digester. To promote bacterial activity, the digester must maintain a temperature of at least 68° F. Using higher temperatures, up to 150° F, shortens processing time and reduces the required volume of the tank by 25 to 40 percent. However, there are more species of anaerobic bacteria that thrive in the temperature range of a standard mesophilic design (95-100˚F) than there are species that thrive at a higher thermophilic design (125-150˚F). High-temperature digesters are also more prone to upset because of temperature fluctuations and their successful operation requires close monitoring and diligent maintenance.

Dynamic has evaluated many types of anaerobic digesters in projects across the United States, including Complete Stirred Tank Reactor (CSTR), Covered Lagoon, Batch Digester, Plug Flow Digester, Up flow Anaerobic Sludge Blanket (UASB), Anaerobic Sequencing Batch Reactor (ASBR), and others. Examination of four anaerobic digester alternatives is included in the following breakdown.

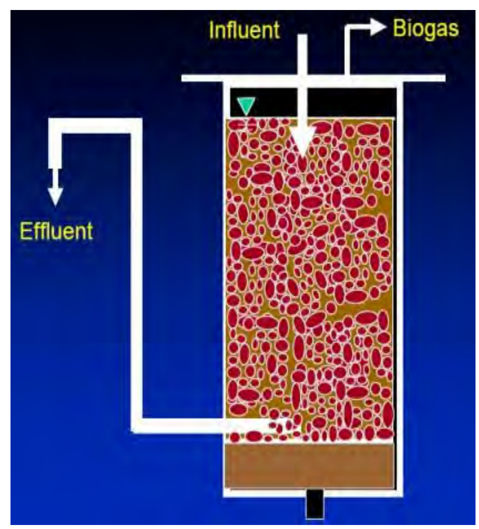
4.1.1 Complete Stirred Tank Reactor

The Complete Stirred Tank Reactor (also referred to as Complete Mix) is a large, concrete or steel circular container. Today's complete mix digesters can handle organic wastes with total solid concentrations of 3% to 14%. Complete mix digesters can be operated at either the mesophilic or thermophilic temperature range with a hydraulic retention time (HRT) as brief as 10-20 days. This technology type is mature with a well understood economic and investment profile. The figure to the right represents the general configuration of a complete mix approach.



4.1.2 Fixed Film Digester

Flushed dairy nutrient water defined as the liquid fraction after particulate solids are removed is usually too dilute for conventional anaerobic digestion systems. One practical alternative is to apply high-rate anaerobic digestion technology, such as fixed film digestion, to recover energy and treat the flushed dairy nutrient wastewater at much shorter residence times (less than 3 days) than that allowed by conventional technologies.

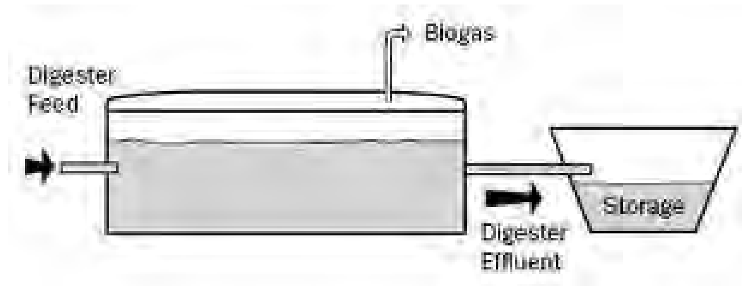


The basic fixed film digester design consists of a tank packed with inert media on which a consortia or colony of bacteria attach and grow as a stable, robust biofilm. As influent passes through the high surface area, high bioavailability, and media-filled reactor, the anaerobic biomass converts/metabolizes organic matter in the nutrient water to biogas. Immobilization of bacteria as a biofilm prevents washout of slower growing cells and provides biomass retention independent of hydraulic retention time. Fixed film digesters are well suited for treating large volumes of dilute wastewater because large numbers of bacteria can be concentrated inside smaller digesters operating at shorter hydraulic retention times than would be needed to achieve the same degree of treatment with conventional anaerobic reactors.

Generally, the fixed film design is suitable for any livestock waste that is subject to dilution with water for transport or processing or the liquid fractions from a physical separation process. Also, fixed film reactors have a smaller footprint than conventional designs; an important factor where land availability is limited. This design is the least common type of digester found in the agricultural industry.

4.1.3 Plug Flow Digester

A typical plug flow digester design consists of a covered reactor where the material to be digested enters at one end of the tank and exits at the opposite. The nutrient stream is added daily to one end of the digester and an equal volume of digested nutrients are forced out the other end. Plug flow digesters work best for dairy manure with 8-14% total solids.

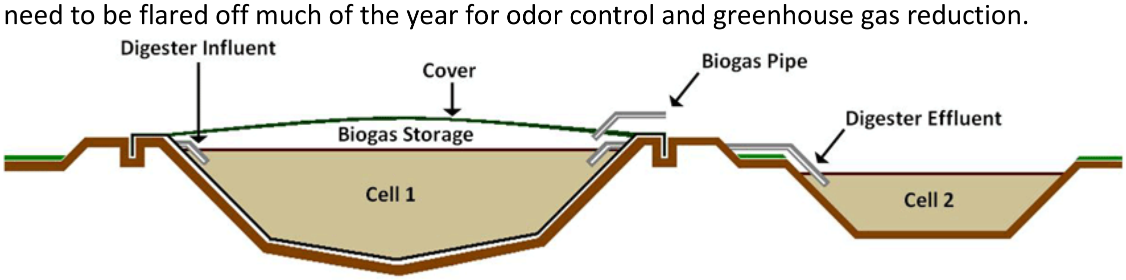


A gas mixing system was incorporated into the plug flow concept to create the modified plug flow design. This type of digester design is the most common technology in ag-based installations in the U.S.

4.1.4 Covered Lagoon Digester

A covered lagoon digester is a large anaerobic holding pond (not a storage pond or basin) with a long retention time and a high dilution factor.

Typically, covered lagoons are used with flush manure collection systems that discharge manure at 0.5-2% total solids. The in-ground, clay or poly lined lagoon is covered with a flexible or floating gas tight cover generally made of geosynthetic material. These geomembranes allow them to conform to most any size and shape. They are not heated and considered ambient temperature digesters. Retention time is usually 30– 45 days or longer depending on lagoon size. In climates that have elevated year round temperatures, such as southern and western U.S., these digesters can produce stable, reduced odor, nutrient rich effluent for application on fields and crops, pathogen and weed seed reduction, and biogas for farm energy use. Very large lagoons in hot climates may produce sufficient quantity, quality, and consistency of biogas to justify further processing of the biogas. In areas with cooler climates, waste digestion, odor control, and gas production will be less consistent and the low quality gas may need to be flared off much of the year for odor control and greenhouse gas reduction.



Due to the seasonality of weather and cooler climate, the covered lagoon digester is not a viable option to optimize biogas production in Wisconsin.

The Plug Flow, Fixed Film, and Complete Mix Systems will perform well when matched with the type of manure the dairies are creating. However, the Fixed Film system has not been well commercialized utilizing dairy manure. The two options that fit the total solid content of the dairies' manure stream are Plug Flow and Complete Mix. Both of these systems are specifically designed to maximize methane output utilizing a standard mesophilic digester.

4.2 Advanced Separation Technology

The challenge, as stated earlier, is to separate the nutrients from the water to create economically usable products and clean water. In many cases, this is accomplished through a four-step process. The first three steps are focused on suspended solids removal while the final step is focused on dissolved solids removal as illustrated in Figure 4.2.1.

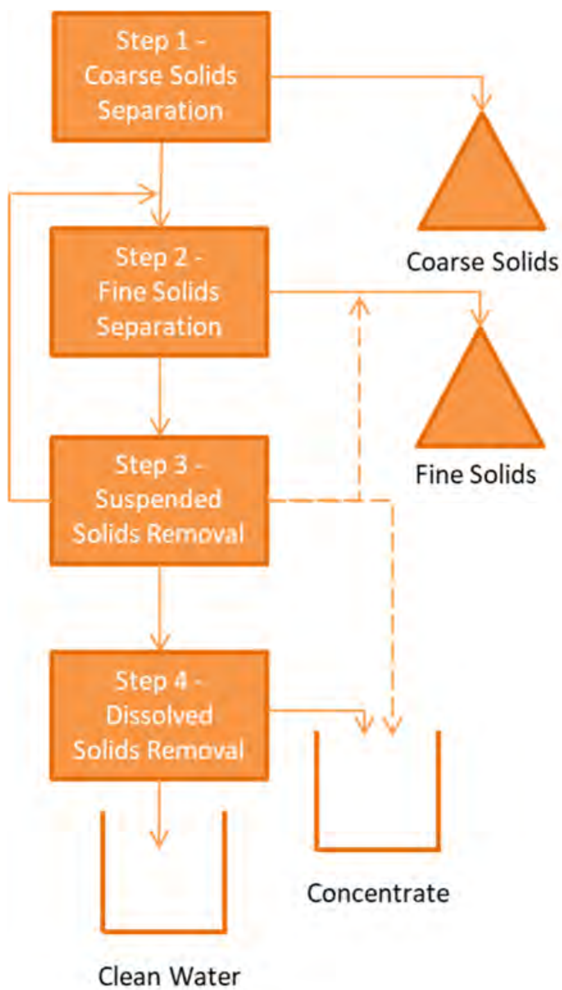


Figure 4.2.1: Advanced Separation Stages

DYNAMIC RENEWABLES

4.2.1 Coarse Solids Separation

Coarse solids separation is the first step in the process. As the name implies, the first step removes the largest particles, typically about 1/8" and larger. Many different types of equipment can be used for this step including static slope screens, drum screens, screw presses, and different combinations of these pieces of equipment. With each of these pieces of equipment, there are trade-offs between ease of use, cost to operate, and labor required for operation.

Picture 4.2.1.1: Bauer Screw Press

From our perspective, screw presses are the most effective means of capturing coarse solids and reducing their moisture content for use as bedding or sending them to a drying system to further reduce their moisture content. The lower the moisture content of the solids sent to the drying operation, greater throughput and less energy consumption is required by the dryer. A screw press can typically produce about 68-72% moisture solids.

4.2.2 Fine Solids Separation

Fine solids separation is the second step in the process. By removing the fine solids from the manure stream, up to 95% of the phosphorus contained in the manure stream can be segregated from the nitrogen and potassium. This step creates a phosphorus rich cake product and a nitrogen and potassium liquid product typically referred to as "tea water". If the farm is set up for irrigation, the tea water can be run through the irrigation system to add nitrogen and potassium to the crops as they are needed. This step is also used to reduce the amount of suspended solids in the manure stream to prepare it for further processing in an ultrafiltration process. Fine solids separation systems often use polymers and coagulants to bind together the finest particles into a larger particle to allow it to be separated.

Based on current technology in the marketplace, the following systems would be considered commercially available solutions for this step of the process: Trident Nutrient Recovery System, Livestock Water Recycling First Wave System, Digested Organics SRDU, and centrifugal separation systems.

The Trident system utilizes a dissolved air floatation (DAF) tank to float the fine particles to the surface after they have been mixed with the polymer. There are a series of skimmers that continuously skim the solids off of the surface of the tank. The liquids from the tank overflow a weir wall at one end of the tank while the solids are skimmed into a collection trough at the other end of the tank. The solids come off the system at about 90% moisture. These solids typically contain 70-90% of the phosphorus that was originally in the manure. These solids can be pumped into a storage tank and blended with the concentrate from the next steps of separation for land application or pressed into a cake. Trident also provides their proprietary polymers for the system and the polymer make-down unit.

Picture 4.2.2.1: Trident DAF System

Another option for this application is the LWR First Wave system. This system blends the polymer with the manure in mixing chambers and then they overflow onto an inclined screen. On the bottom side of the screen is a spray bar that uses the liquids that just passed through the screen to spray it off to keep it clean. At the bottom of the screen is a collection hopper which can have an optional screw press to gently squeeze the free water out of the solids to create a stackable cake.

Picture 4.2.2.2: LWR First Wave Separation System

The Digested Organics SRDU system blends the polymer with the manure in mixing chambers with the injection of compressed air to enhance the contact between the solids and the polymers. The mixture is released into a floatation tank where the flocculated solids are mechanically scraped from the top of the tank and the liquids flow out of the tank. The separated solids can be further dried through a multi-disk press to produce a stackable cake product.

Picture 4.2.2.3: Digested Organics SRDU

Centrifuges use centrifugal force to separate the fine particles from the liquids. They typically spin at speeds of 1,800 to 3,600 rpm. The material enters one end of the spinning bowl assembly and the force pushes the solids to the outside of the bowl assembly. Inside the bowl assembly, a scroll is turning at a few rpm differential than the bowl to scrape the solids from the sidewall of the bowl and convey them to the solids discharge end of the bowl. As the liquids travel down the other end of the machine, they exit out ports that control the pool depth inside the bowl. In many cases, polymers and coagulants are added to the feed stream to achieve higher levels of solids capture to prevent premature fouling of the next stage of separation.

Picture 4.2.2.4: Centrisys Centrifuge Equipment

4.2.3 Fiber Drying System

When using solids for bedding, our experience has been that there is a direct link between moisture content and somatic cell counts. Mechanical separation systems typically don't get the coarse fiber any drier than 65% moisture. Most farms that are having success with solids as bedding are drying it to 55-60% moisture. Drying much lower than 50% typically creates dust problems in the barns. Once the material has been dried sufficiently to 55-60%, the reduction in somatic cell count reaches a point of diminishing marginal return where additional drying no longer reduces the somatic cell counts.

Picture 4.2.3.1: IEC Fiber Drying Equipment

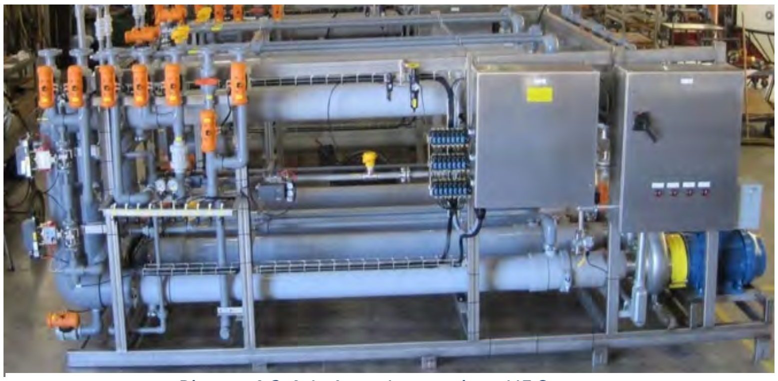
In addition to drying the coarse fiber for bedding, the fine solids can also be processed through the dryer to reduce the moisture content to make transporting the cake off the farm more economical. This option is often selected when the farm is limited by phosphorus in their nutrient management plan. By drying the fine solids to about 50% moisture, a typical semi-trailer will be full and near its maximum weight/volume ratio.

There are numerous dryer manufacturers in the area including Baker-Rullman in Watertown, WI, FEECO in Green Bay WI, Innovative Environmental Companies (IEC) in Rockford, IL, and McLanahan Corporation with multiple dealers in Wisconsin. All of these suppliers have multiple years of experience in drying products such as wood chips, sawdust, or municipal bio-solids and currently have installations drying dairy manure solids.

4.2.4 Suspended Solids Removal System

The third stage of advanced separation is the removal of the very fine suspended solids from the manure stream. This step is typically utilized as a preparatory step prior to reverse osmosis when the goal is to create clean water. There are multiple technologies that can perform this function such as bag filters, sand filters, membrane bioreactors (MBR), and ultrafiltration (UF). From our experience, UF systems provide the best operational results since they typically have a lower operating cost although they have a higher capital cost and operate at a higher efficiency which allows for a greater percentage of clean water recovery. UF systems are designed to remove particles down to 0.1 to 0.01 microns in size.

A UF system consists of multiple housings with a membrane in each housing. A pump either pushes or pulls the process water through the membrane. The solids are trapped on the outside of the membrane and the water without the suspended solids is allowed to pass through the membrane. The water that passes through the UF membrane is called permeate. Once the differential pressure across the membrane reaches a certain point, the UF system backwashes the membranes with the permeate that it created to wash the particles off of the membrane surface. This backwash water is called the UF concentrate. The UF membrane system continually repeats this process. The UF concentrate can be recycled back to the start of the fine solids separation process or sent directly to storage for land application.



Picture 4.2.4.1: Aqua Innovations UF System

Manufacturers of this equipment such as GE, Dow, Evoqua, and Xylem have considerable experience in municipal or industrial applications with this technology, but limited experience with manure. Aqua Innovations in Beloit, WI and Digested Organics in Ann Arbor, MI are suppliers that are currently in this space and have multiple years of experience processing dairy manure.

4.2.5 Dissolved Solids Removal System

The final stage in advanced separation is the separation of the dissolved solids from the clean water. This is typically done with a reverse osmosis (RO) system. An RO system uses membranes to filter out salts and particles less than 0.001 microns. Most RO systems in this application use either brackish water membranes operating between 200-400 psi or salt water membranes operating over 1,000 psi. They are typically designed to provide 70-80% clean water recovery of the incoming stream. This yields 50-65% clean water of the original manure stream sent to the first separation stage.

The RO system uses a high pressure pump on the feed side of the membrane system. As the feed material is pressurized on the outside of the membranes, the clean water is able flow to the center of the membrane tube and out of the system. The clean water is referred to as the permeate. The remaining dissolved solids that don't pass through the membranes are rejected from the system as the concentrate. The concentrate contains the soluble nitrogen and potassium. Most suppliers also inject an acid prior to or in one of the stages of the RO to tie up the ammonia that may be present and convert it to a stabilized ammonium. The concentrate typically contains 2-3 times the concentration of nitrogen and potassium as the original manure stream, is readily available to crops, and can easily be irrigated since it doesn't contain any suspended solids. Again, RO systems are typically packaged by suppliers as part of a complete system.

Picture 4.2.5.1: Aqua Innovations Reverse Osmosis System

4.2.6 Emerging Technologies

Sedron Technologies developed the Varcor system which is a unique process for processing dairy manure following coarse solids separation. The Varcor technology is based on the process of mechanical vapor recompression. The solid and liquid fractions are separated through thermal evaporation and the resulting vapor is sent to a compressor for mechanical recompression. This process creates clean water, dry solids, and a concentrated organic nitrogen fertilizer product. This solution is ideal for farms with excess nutrients or a limited land base.

Another emerging technology is utilizing pyrolysis for the separated solids and creating biochar. This creates a value-added soil amendment product which contains up to 95% of the phosphorus from the manure and can be reduced to about 10% of the original mass of the separated solids. At the present time, this technology does not economically scale down for systems less than about 20,000 cows.

4.3 Biogas Upgrading Technology

The current trend is to upgrade the biogas produced by the anaerobic digestion process to renewable natural gas (RNG). Biogas is comprised of methane, carbon dioxide, hydrogen sulfide, and water. Since natural gas is about 97% methane, the carbon dioxide, hydrogen sulfide, and water needs to be removed to creating a 97-99% methane product.

4.3.1 Hydrogen Sulfide Removal

Hydrogen sulfide can be removed from the biogas in a number of different ways. In some systems, the hydrogen sulfide is treated inside the digester tank with the use of an iron salt solution such as ferric chloride. The ferric reacts with the sulfur to create an iron sulfide that precipitates out in the slurry. This can be a simple means of controlling hydrogen sulfide but can be costly depending on the level of hydrogen sulfide in the biogas. Safe storage and handling of the ferric also needs to be addressed.

When removing the hydrogen sulfide from the biogas stream, one of the simplest and lowest capital cost options is the use of an iron sponge. This is typically a vessel filled with iron impregnated media that reacts with the hydrogen sulfide as the biogas is passing through the vessel. The sulfur reacts with the iron and attaches to the media. Once all the iron in the media is consumed, the media needs replacement. The challenge with this system is the frequency and difficulty of replacing the media.

To avoid the frequent media changes, technologies such biological or chemical reactor systems are used. These are typically two vessel systems where the biogas enters one of the vessels and reacts with a solution or media to precipitate out the sulfur. The sulfur rich solution is then transferred to the second vessel where the solution is regenerated to release the sulfur from the solution. The solution is then reused in the first vessel and remains in the closed loop. The sulfur is removed from the second vessel as a slurry. These system have a higher capital cost than an iron sponge, but typically have a lower operating cost. The quantity of biogas and the amount of hydrogen sulfide in the biogas will typically dictate which technology is the most cost effective in that application.

4.3.2 Water Removal

Water in the form of vapor is typically removed from the biogas in a desiccant dryer. Due to the strict requirements on gas moisture in the pipeline systems, these dryers are used to achieve a dew point of negative 40°F. The towers are filled with vapor-absorbing beads to absorb the moisture. These systems are typically in twin tower arrangements. The gas passes through one of the towers until the beads are fully saturated. The system switches to the other tower while the saturated tower runs through a regeneration process to remove the water from the beads. Once the second tower is saturated, it switches back to the first tower and the process continually repeats.

4.3.3 Carbon Dioxide Removal

In most biogas upgrading systems, the carbon dioxide is separated from the methane once the hydrogen sulfide and water are removed. There are predominately three technologies used for separating the carbon dioxide from the methane: membranes, pressure swing adsorption, and absorption towers.

Membrane separation technology is one of the most common means of separating the methane from the carbon dioxide, especially in lower flow rates of biogas. The membranes function as a molecular sieve allowing the carbon dioxide to pass through and retaining the methane. In order to achieve the high purity of methane required to substitute it as natural gas, it typically is processed by a three-stage membrane system to achieve over 98% methane capture. These systems are relatively simple in construction and easy to operate. Since compression is required for the separation process, power consumption is typically the largest operating cost of these systems.

Pressure swing adsorption (PSA) consists of an array of vessels filled with adsorbent media that traps the carbon dioxide and other remaining contaminants while under pressure allowing the methane to pass through. The media is regenerated by releasing the pressure and putting it under vacuum which releases the contaminants from the media. This process is continually repeated through the multiple vessels to process the designed rate of biogas. The advantage of this technology is it has the ability to remove small amounts of nitrogen and oxygen from the biogas stream unlike membranes or absorption towers.

For high biogas flows, typically over 1,000 scfm, absorption towers are used. These systems utilize towers where either water or an amine solution runs counter current to the biogas flow. As the biogas passes through the solution, the carbon dioxide is trapped in the solution and the methane passes through. The water or amine solution is then regenerated in another tower and reused in the closed loop process. These systems typically have high capital costs but low operating costs. This is why they are typically used in higher flow applications.

5.0 Market Analysis

5.1 Community Digestion Facilities

Numerous community manure digester systems have been implemented over the past 20 years. One of the first manure -based community digester projects was built in 2001 by California's Inland Empire Utilities Agency (IEUA). This project initially generated renewable electricity from the biogas utilizing combined heat and power (CHP) units and was owned and operated by IEUA. In 2012, IEUA entered into a public-private partnership and converted the facility from using CHPs to using fuel cells.

The Port of Tillamook Bay built a community manure digester in 2012. The system was shut down by the county commissioners in 2016. It was reopened in 2018 under private operation and management. It has had challenges coming back online. It is in the process of being converted from making renewable electricity to renewable natural gas.

In 2011, Dane County, Wisconsin led the efforts to develop its first of two community digestion systems. The first system was located north of Madison near Waunakee. It consisted of three dairy farms that piped their manure to and from the system. Dane County provided the project with $3 million in funding to reduce the phosphorus that was returned to the participating farms. The project was privately owned and operated. The project has been sold twice since it was initially built and has been converted to produce renewable natural gas rather than renewable electricity. The renewable natural gas is trucked and injected into the pipeline at the County-owned injection point at the County landfill.

Following up on the knowledge gained from their first system, Dane County developed a second community digester system that was built near Middleton, WI in 2013. In addition to making renewable electricity, this system included a centrifuge following a set of screw presses and a large compost building to pull more of the solids from the digestate with the goal of further reducing the phosphorus in the watershed. In 2018, the County added a water treatment system with the goal of removing 40-50% of the water from the manure and discharging it to the Pheasant Branch Creek. This system could make dischargeable water but struggled to meet the goals of 40-50% volume reduction. This facility was sold in 2020 and was upgraded to include solar panels and converted from making renewable electricity from the biogas to making renewable natural gas. The renewable natural gas is trucked and injected into the pipeline at the County-owned injection point at the County landfill.

The Tillamook and Dane County facilities are similar in size to the potential project in Washington County. In most of these cases, the operating costs of the facilities were greater than the initial projections which created economic challenges. A few of the lessons learned from these projects that could be applied to this project include having a cost-effective means to manage and export the separated solids from the project site. If a water treatment system is added to the project, research the various vendors in the market and learn which technology best fits with this project. Most of the previous projects have been converted from making renewable electricity to renewable natural gas which provides better overall economics to these projects.

5.2 Renewable Natural Gas (RNG)

Removing carbon dioxide and impurities such as hydrogen sulfide to bring the methane content up to the same specifications required of fossil-based natural gas results in high-Btu gas that is pipeline quality and can be used for transportation fuel when compressed (CNG) or liquefied (LNG). CNG has been the most common fuel used by fleets where medium-duty trucks are close to the fueling station, such as city fleets, local delivery trucks and waste haulers. LNG is typically used for heavy-duty trucks traveling along the growing network of LNG fueling stations. RNG currently sells at premiums over traditional natural gas due to the value of the environmental credits produced through the use of renewable fuels.

RNG is eligible for renewable identification numbers (RINs) that are used to identify and track biofuel production that obligated parties need to demonstrate blending for compliance with the renewable fuel standard (RFS). D3 of the renewable fuel standard is the RIN code for cellulosic ethanol, cellulosic diesel, and renewable natural gas produced from animal manure. RINs are environmental credits that are used to demonstrate compliance with renewable fuel standards.

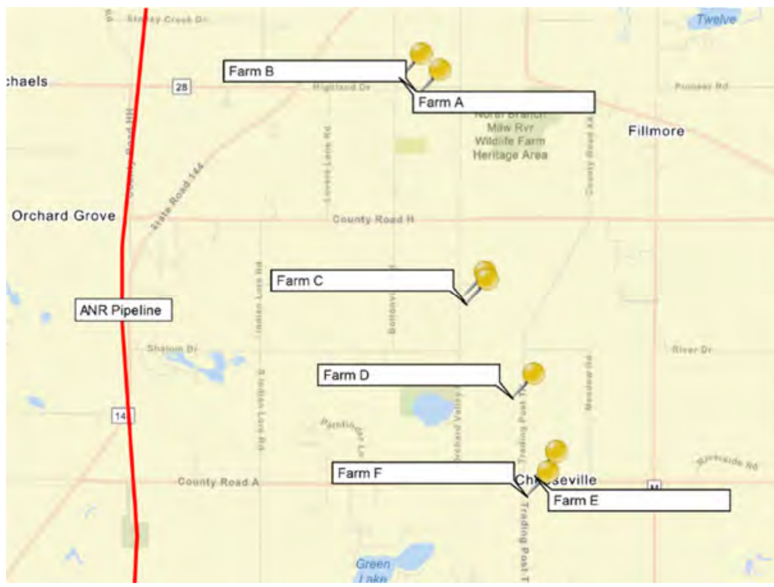


Figure 5.2.1: Map showing natural gas pipelines near Cluster

In addition to the RINs, renewable natural gas is also eligible for credit with California's Low Carbon Fuel Standard (LCFS). The LCFS was developed to encourage the use of cleaner low-carbon fuels in California and to encourage the production of these fuels. The LCFS standards are expressed in terms of the carbon intensity (CI) of gasoline and diesel fuel and their respective substitutes. The LCFS is performance-based and fuel-neutral, allowing the market to determine how the carbon intensity of California's transportation fuels will be reduced.[4]

The value of qualified renewable natural gas fluctuates based on the trading prices of three primary revenue components.

[4] California Air Resources Board; https://www.arb.ca.gov/fuels/lcfs/lcf/htm

1. Commodity Gas Price – Natural Gas Intelligence charts indicate that natural gas has generally traded between $2.00 and $3.00 per MMBtu over the past few months, with recent trading at about $2.50/MMBtu.[5]

2. RIN Credit – D3 RIN credits are trading at about $2.15 with fluctuations generally between $1.90 and $2.30[6] For calculation purposes, there are approximately 11.72 RINs applicable to a single MMBtu.

3. California LCFS Credit – LCFS credits have recently traded between $60 and $90 per ton. Pricing peaked over $200/ton in early 2020 and hit a low of just over $60/ton in late 2022. Pricing is currently averaging about $80/ton.[7]

At current trading prices for these components, RNG has the potential to be sold on a merchant basis of $35-$45/MMBtu after accounting for brokerage fees. Since most investors are looking for secured revenue, companies that specialize in environmental attribute trading will typically offer five to ten year fixed price contracts for the RNG. Since these companies are taking the price risk and uncertainty of the market over the next five to ten years, the price is often significantly lower than the current market pricing.

5.3 Renewable Electricity

Most of the digesters that were built up until 2013 used the biogas to produce renewable electricity. At that time, the utilities were willing to pay a premium rate for the renewable electricity. In the last few years, the utilities have met their renewable standards and are no longer willing to pay a premium. Currently, the local utility is offering to purchase the power at $0.03/kWh which does not create a favorable economic return on investment.

The EPA has proposed rules that would allow biogas-based renewable electricity to be eligible to participate in the RIN program by allowing electric vehicle manufacturers to enter into contracts with biogas electricity producers. These projects would produce eRINs. This incentive could potentially make producing electricity from biogas feasible again. However, the EPA has failed to establish the pathway to allow eRINs as part of the RFS program.

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[5] U.S Energy Information Administration Natural Gas Weekly Update. https://www.eia.gov/naturalgas/weekly/
[6] PFL Weekly Recap. Progressive Fuels Limited, 1865 Veterans Park Dr., Suite 303, Naples, FL 34109. www.progressivefuelslimited.com
[7] California Air Resources Board; https://www.arb.ca.gov/fuels/lcfs/lcfs.htm

5.4 Direct Use

Direct use is typically the lowest capital cost use for the biogas. The challenge in the current market environment with low natural gas costs is that direct use does not provide a significant payback on the investment when simply offsetting the purchase of natural gas. Typically, the most feasible direct use of biogas is to co-locate the biogas plant with a large industrial natural gas user that also is willing to pay a premium to offset their natural gas usage with renewable biogas. Based on the location of the potential project, there aren't any large industrial gas users in the area.

5.5 Separated Solids

The separated solids from the proposed project are typically used as animal bedding or sold as a peat moss replacement to the horticultural industry. For both these uses, the customers prefer the material have less than 60% moisture content. Most of the farms we met with were open to the concept of switching from sand bedding to dried solids bedding, and the project should strongly pursue this option since moving and handling sand laden manure is significantly more expensive for the project.

Selling the separated solids has been one of the challenges of community-based anaerobic digestion systems since the participating farms only need about half of the solids produced for bedding. The nutrient value is relatively low so the solids aren't in high demand as a fertilizer product for farm fields. Other sites have tried stacking or windrow composting to achieve the desired moisture levels of the solids with limited success especially in the winter months. Others have tried selling the solids into niche markets. The challenge with niche markets is the ability for the plant to provide the material on a regular basis at the required quality and for the customers to maintain a consistent demand for the product. Another challenge is matching the production with the demand. Some have tried adding additional nutrients to the solids and pelletizing them as a source of organic fertilizer for farmers. The challenge becomes storing the material for extended periods of time when they are not in demand or cannot be applied to farm fields. Other technologies such as pyrolysis and incineration are available and convert the solids into biochar but need significantly higher volumes of feedstock to be economically viable. Community-based systems produce a significant quantity of separated solids year round and need to find a market that can take the anticipated production year round.

6.0 Project Selection and Evaluation

6.1 Farm Manure Management

The farms in the proposed cluster utilize either a scrape or vac truck manure collection system. Most of the farms transfer their manure from the barns to long-term manure storage. Manure is land applied in the spring to a portion of their fields and then again in the late summer and fall as the crops are harvested. Their goal is to empty their storage as completely as possible by the end of November/early December to allow them to have enough storage capacity to make it until spring.

The liquid manure is land applied primarily with three methods. For the fields within a couple miles of the farm, the manure is pumped directly from the storage to the field where it is applied. For the fields further away from the farm, it is loaded onto a truck next to the manure storage on the farm and transported to the field where the truck directly spreads it in the field. The other option for unloading the trucks is depositing it into a frac tank and then it is pumped to the applicator in the field.

The cost for land application directly from the manure storage to the field is about $0.01/gallon. Assuming the cows produce about 29 gallons/cow/day and a cow is 1.4 animal units (AU), it costs about $76/AU/yr. The cost to land apply within about 5 miles using a truck is about $0.02/gallon or $151/AU/yr. Hauling up to about 10 miles each way costs about $0.03/gallon or $227/AU/yr. Some farms are hauling over 10 miles to distribute manure and the costs increase quickly.

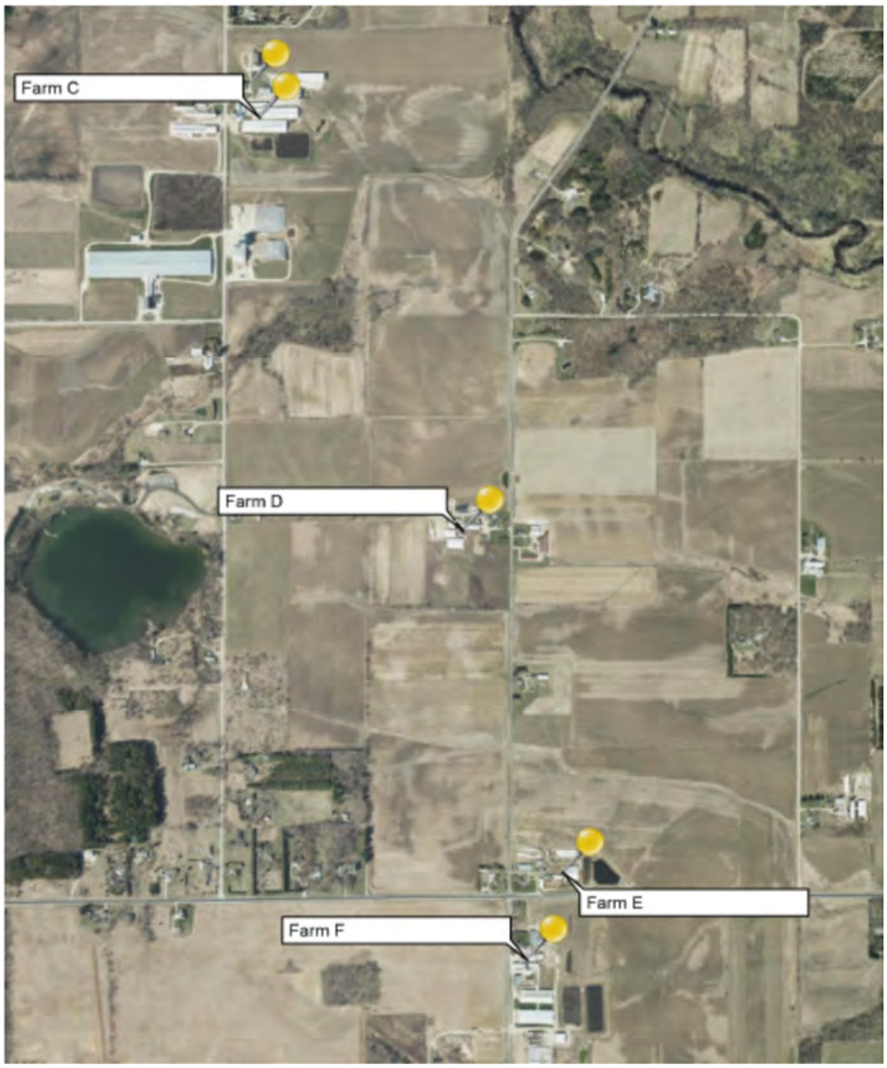
The two largest variable costs in manure handling and application are labor and diesel fuel. Over the past 10 years, the cost of non-supervisory farm labor has increased 21.8%[8]. The cost of diesel fuel has increased 32.5%[9]. Using the past 10 years data and projecting forward, it can be assumed the cost to apply manure will increase by about 25-30% over the next 10 years.

The potential participating farms expressed concerns over increased residential growth in areas they formerly farmed and the concern that some of the land they currently rent will be converted to residential land over the next 10 years. This will increase their operating costs since they will continue to haul manure further as land near their farm gets developed. Another concern included hauling manure through West Bend to get to farm fields they have on the west side of the city. The farms with nutrient management plans expressed concerns over the phosphorus loading in certain areas and potential future restrictions on manure applications in those areas.

[8] United States Department of Agriculture – Economic Research Center (2013 – 2022)
[9] United States Energy Information Administration (2013-2022)

6.2 Site Selection/Recommendation

The County identified the cluster of farms to focus on for this feasibility study. The distance from Farms A and B to Farm C is approximately 2 to 2.5 miles depending on the route. The budget estimate for installing a pipeline system with redundant pipes and cleanouts is approximately $1 million/mile. The cost to operate the pipeline is about $0.005/gallon pumped assuming the farms are not using sand bedding. Trucking the manure to and from the project site is similar to the cost of manure land application. Trucked farms within 5 miles of the facility can haul the manure for about $0.02/gallon while those between 5-10 miles are about $0.03/gallon. Farms beyond 10 miles will be at least $0.04/gallon.



Most of the cows for the cluster are at Farms C and F. From a siting perspective, the most viable options are to locate the potential project at either Farm C, Farm F, or somewhere between the two farms.

Additional factors such as farm participation, road access, proximity to neighbors, and town zoning will all need to be evaluated for final site selection. ANR has a natural gas transmission line approximately 1 mile west of the cluster that could be used to inject the RNG. WE Energies also has a natural gas distribution line about 6 miles from the cluster that could be used to inject the RNG.

Once the site is selected, the economics of piping the manure to and from the site versus trucking the manure can be evaluated in detail. In this feasibility study, it is assumed the project will be taking in all of the liquid manure from the project participants and will be returning about 50% of the supplied volume in the form of a concentrated phosphorus product and a concentrated nitrogen and potassium product. The remaining 50% will be discharged as clean water to a local waterway, used as irrigation water by the surrounding farms, or used as process water by the plant and surrounding farms.

6.3 Process Flow Diagram

The development process started with creating a high-level process flow diagram to outline the key processes that would be required for the proposed project.

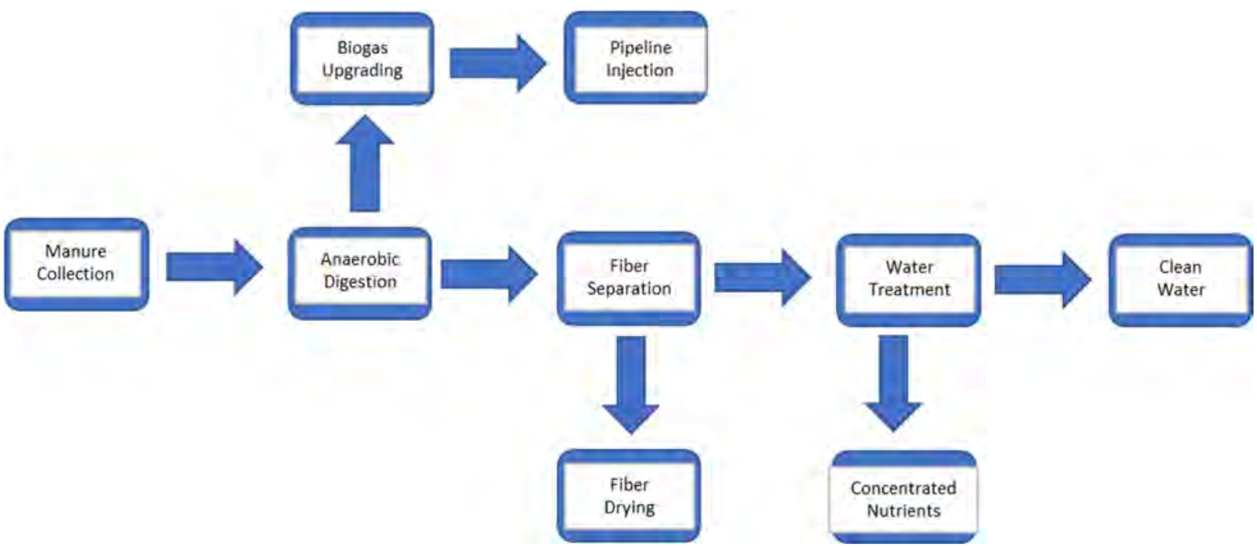


Figure 6.3.1: Project Process Flow Diagram

Based on the process flow diagram, we contacted technology providers to develop a budgetary capital cost for the proposed project. Installation costs were estimated based on our experience installing projects of this size and scope.

6.4 Project Volume and Energy Projections for Digestion

Based on input from the potential project farms, this information was used to estimate the amount of manure that could be digested and the amount of RNG that could be produced. The following table summarizes the calculations for both manure and RNG production.

Table 6.4.1: Project Volume and Energy Projections

Input - Farm Characteristics						
Project Names	**Farms A & B**	**Farm C**	**Farm D**	**Farm E**	**Farm F**	
Input - Headcount						
Milking Cows	**710**	**2,650**	**150**	**220**	**900**	
Dry Cows	**80**	**362**	**20**	**20**	**120**	
Heifer Cows	**0**	**903**	**0**	**0**	**1,000**	
Total	**790**	**3,915**	**170**	**240**	**2,020**	
Input - Technical Parameters						
Milk Production (lbs/day/cow)	**75**	**85**	**80**	**75**	**85**	
Availability	*95%*	*95%*	*95%*	*95%*	*95%*	
Volatile Solids Destruction Rate	*45%*	*45%*	*45%*	*45%*	*45%*	
Cubic Feet of Methane per lb of VS Destroyed	*8.0*	*8.0*	*8.0*	*8.0*	*8.0*	
Methane Content	*60%*	*60%*	*60%*	*60%*	*60%*	
Mass and Energy Balance - Active Farms						
	Farms A & B	**Farm C**	**Farm D**	**Farm E**	**Farm F**	**Total**
Milking Cows	710	2,650	150	220	900	**4,630**
Dry Cows	80	362	20	20	120	**602**
Heifers	0	903	0	0	1,000	**1,903**
Total Cows	**790**	**3,915**	**170**	**240**	**2,020**	**7,135**
Manure - Milking Cow (lbs/day)	166	196	184	166	196	
Manure - Dry Cow (lbs/day)	129	152	144	129	152	
Manure - Heifer (lbs/day)	71	84	79	71	84	
Manure Production As Excreted (lbs/day)	**128,218**	**649,187**	**30,470**	**39,110**	**278,314**	**1,125,299**
Total Solids (%)	12%	12%	12%	12%	12%	
Total Volatile Solids (%)	80%	80%	80%	80%	80%	
Total Manure Volatile Solids to Digester (lbs/day)	**12,309**	**62,322**	**2,925**	**3,755**	**26,718**	**108,029**
Volatile Solids Converted to Methane (lbs/day)	5,539	28,045	1,316	1,690	12,023	
Methane Generated from Manure (cft/day)	**44,312**	**224,359**	**10,531**	**13,516**	**96,185**	**388,903**
MMBtu/day	**44**	**224**	**11**	**14**	**96**	**389**
MMBtu/year	**16,174**	**81,891**	**3,844**	**4,933**	**35,108**	**141,950**
MMBtu/year - Availability adjusted	**15,365**	**77,797**	**3,651**	**4,687**	**33,352**	**134,852**
Biogas - scfd	73,854	373,932	17,551	22,527	160,309	**648,172**
Biogas - scfm	51	260	12	16	111	**450**
Biogas - scfd - Availability adjusted	70,161	355,235	16,673	21,401	152,293	**615,764**
Biogas - scfm - Availability adjusted	49	247	12	15	106	**428**
MMBtu/cow/year	**20**	**23**	**22**	**20**	**23**	**23**
Gallons Manure/Day	**15,448**	**78,215**	**3,671**	**4,712**	**33,532**	**135,578**
Gallons Manure/Year	**5,638,520**	**28,548,588**	**1,339,963**	**1,719,880**	**12,239,101**	**49,486,052**
Parlor Water - Gallons/Cow	5	6	6	6	6	
Parlor Water - Gallons/Day	3,550	15,900	900	1,320	5,400	**27,070**
Parlor Water - Gallons/Year	**1,295,750**	**5,803,500**	**328,500**	**481,800**	**1,971,000**	**9,880,550**
Total Feedstock Volume - Gallons/Day	18,998	94,115	4,571	6,032	38,932	**162,648**
Total Feedstock Volume - Gallons/Year	**6,934,270**	**34,352,088**	**1,668,463**	**2,201,680**	**14,210,101**	**59,366,602**
Gallons per Day to Digester	**18,998**	**94,115**	**4,571**	**6,032**	**38,932**	**162,648**

Based on the projections above, the proposed project will need to process about 162,700 gallons per day of manure which will create about 389 MMBtu/day of RNG. This information was used in sizing the digestion system, biogas upgrading system, and water treatment system in the following sections.

6.5 Capital Cost Estimation

Capital cost estimates were constructed by dividing the proposed project into 12 construction categories. Each of these categories was assigned a unit cost that was derived utilizing historical data and/or current budgetary quotations from equipment vendors. Of the individual farms identified in the cluster, the only two that are large enough to potentially be economically viable are Farm C and Farm F. Below are the estimated capital costs of the individual farm systems and the capital cost for the project cluster.

Table 6.5.1: Itemized capital cost estimate for project

Capital Cost Estimate			
Description	Farm C Cost Estimate	Farm F Cost Estimate	Cluster Cost Estimate
Remote Farm Manure Reception/Pipelines	$0	$0	$4,850,000
Anaerobic Digestion System	$5,600,000	$3,500,000	$9,250,000
Site Manure Collection/Transfer	$580,000	$990,000	$2,500,000
Electrical Subcontractor	$1,680,000	$1,150,000	$2,200,000
Mechanical/Plumbing Subcontractor	$2,800,000	$2,400,000	$3,700,000
Civil/Excavation Subcontractor	$2,250,000	$1,700,000	$1,500,000
Engineering/Development Costs	$1,900,000	$1,850,000	$3,000,000
Separation and Drying System	$1,250,000	$1,100,000	$2,500,000
Water Treatment System	$0	$0	$5,000,000
Gas Upgrading & Compression	$3,500,000	$3,500,000	$6,800,000
RNG Gas Pipeline	$1,500,000	$1,500,000	$1,500,000
Natural Gas Injection Interconnection	$1,800,000	$1,800,000	$1,800,000
Total Capital Cost	**$22,860,000**	**$19,490,000**	**$44,600,000**

6.6 Operating Cost Estimate

Operating cost estimates were generated based on historically documented data and experience operating anaerobic digestion facilities. Data for equipment that Dynamic does not directly have operating experience with was provided by manufacturers.

Table 6.6.1: Itemized operating cost estimate

Operating Cost Estimate			
Description	Farm C Cost Estimate	Farm F Cost Estimate	Cluster Cost Estimate
Material Processing and Digestion	$493,000	$177,800	$631,900
Gas Conditioning and Compression	$458,300	$165,300	$782,800
Fiber Separation and Drying	$311,000	$242,600	$560,400
Water Treatment	$0	$0	$907,100
Misc. Expenses	$172,500	$107,500	$325,000
Management and Labor	$284,300	$200,300	$495,000
Total Operating Cost	**$1,719,100**	**$893,500**	**$3,702,200**

The operating costs include the cost of rebuilding and replacing components as needed over the life of the project as well as all preventive and corrective maintenance. As the table illustrates, a large portion of the operating costs are associated with the effluent processing post digestion. This creates a challenge with the project financials since the majority of the revenue associated with this plant comes from the gas sales. Included in the operating cost is the separation and drying the separated solids produced by the project. It is estimated that it will cost $50/ton to separate the solids and dry them to 50-55% moisture. For the individual farms, a water treatment system was not included.

Another expense to plan for is decommissioning of the project at the end of its useful life. Projects of this size should budget $1-2 million for decommissioning. This can be in the form of a letter of credit or other financial instrument that provides a level of surety that funds will be available for decommissioning if needed.

6.7 Grants and Incentives Programs

6.7.1 State Level Programs

Focus on Energy provides an incentive for renewable energy projects including biogas projects. For this type of project, the incentive limit is $300,000, 50% of the project cost, or capped at a one year payback. Given the capital cost and simple payback of the proposed project, the limit will be $300,000.

The Fund for Lake Michigan is a non-profit organization that provides grant funds to projects that improve water quality in the Lake Michigan watershed with priority given to project in Southeastern Wisconsin.

Sustain Our Great Lakes supports projects to improve habitats, green space, and water quality in Wisconsin's lake Michigan watershed.

6.7.2 Federal Level Programs

The Rural Energy for America (REAP) program administered by the USDA is one of the largest programs that support anaerobic digestion projects through both grants and guaranteed loans. The program provides grant funding of up to $1 million for renewable energy systems and loan guarantees on up to 75% of the total eligible costs.

The Great lakes Restoration Initiative works to protect and restore the Great lakes. Funds are appropriated to the EPA and the EPA provides funding to other governmental agencies to use the money to support projects.

Tax incentives that support anaerobic digestion projects were included in the Inflation Reduction Act (IRA) that was signed into law on August 6, 2022. Included in this legislation was both an investment tax credit (ITC) and production tax credit (PTC) for biogas projects. At the time of writing this report, the federal government has not issued final guidance on the rules associated with administering these programs, but the details below are the current industry assumptions.

The ITC is a percentage of the total eligible project costs. The ITC can be used to offset the tax liability of the project owner, provided as a direct payment in the form of a tax refund from the federal government, or sold or transferred to a third party. The base ITC is 6% of the eligible project costs. It increases to 30% if prevailing wage and apprenticeship requirements are met during the construction of the project. A 10% bonus is available if the project meets the domestic content requirements. Another 10% bonus is available if the project is built in an energy community.

The facility would also qualify for the PTC for the production of clean transportation fuel if the biogas is converted into RNG and sold as vehicle fuel. The credit applies to fuel produced and sold after December 31, 2024 and before December 31, 2027. The credit is $0.20 per gallon for nonaviation fuel use. This credit is increased by a multiple of five if the prevailing wage and apprenticeship requirements are met.

6.8 Financial Modeling

The source of revenue for this project is renewable natural gas (RNG) sales. Based on all the identified farms participating in the project, the project should generate 135,000 MMBtu/yr. of RNG. Based on the current market rate of $40/MMBtu for the RNG, that provides $5.4 million per year in revenue. In general, investors in these types of projects are looking for a 5 year simple payback or less. The table below summarizes the financial performance without utilizing any of the tax incentives or grant funds.

Table 6.8.1: Simple payback – Base Case - No tax incentives or grant funding

Simple Payback – No tax incentives or grant funds	
Total Revenue	$5,386,000
Total Operating Cost	$3,702,200
Gross Earnings	$1,683,800
Simple Payback	26 years

Assuming the project is eligible to receive a 40% ITC (assumes 90% of projected budget is eligible costs, the ITC value is $16 million), a $300,000 grant from Focus on Energy, and a $1 million grant from the USDA, the following table summarizes this scenario.

Table 6.8.2: Simple payback – Upside - 40% ITC and $1.3 million in grant funding

Simple Payback – With tax incentives and grant funds	
Total Revenue	$5,386,000
Total Operating Cost	$3,702,200
Gross Earnings	$1,683,800
Simple Payback	16 years

Increasing the RNG sales price until the project achieves a simple payback of less than 5 years, a value of $65/MMBtu for the gas is necessary to achieve this hurdle.

Table 6.8.3: Simple payback – Upside - 40% ITC and $1.3 million in grant funding - $65/MMBtu gas

Simple Payback – With tax incentives and grant funds	
Total Revenue	$9,410,000
Total Operating Cost	$3,702,200
Gross Earnings	$5,707,800
Simple Payback	4.8 years

Ten-year proformas were created for Farm C, Farm F, and the cluster. The cluster was modeled with both base case and the upside case with $65/MMBtu gas. The proformas account for the timing of receipt of revenue from the RIN and LCFS markets at startup due to the audit and verification periods once the project is operational. They include a 1% escalator on the O&M expenses and account for federal and state income taxes.

The 10-year proforma for Farm C is strong enough that it could potentially be its own project. The proforma shown does not include the capital or operating expense for a water treatment system. The proforma for Farm F is not as strong and likely will not be its own project unless the economics change.

Table 6.8.4: Proforma– Base Case – Farm C

ANNUAL PROFORMA	Operating Year Year	1 2024	2 2025	3 2026	4 2027	5 2028	6 2029	7 2030	8 2031	9 2032	10 2033
OPERATING MODEL											
Renewable Natural Gas Generation											
Gas Generated	MMBtu	16,303	97,818	97,818	97,818	97,818	97,818	97,818	97,818	97,818	97,818
Ramp Up Rate	%	0%	3%	92%	100%	100%	100%	100%	100%	100%	100%
Net Gas Generation	MMBtu	**0**	**2,717**	**89,666**	**97,818**	**97,818**	**97,818**	**97,818**	**97,818**	**97,818**	**97,818**
Gas Released from Storage		**0**	**0**	**19,020**	**171,181**	**97,818**	**97,818**	**97,818**	**97,818**	**97,818**	**97,818**
Revenue											
Gas Price	$/MMBtu			$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Accrued Gas Revenue	$	$0	$0	$47,550	$427,952	$244,544	$244,544	$244,544	$244,544	$244,544	$244,544
Gas Revenue Received	$	**$0**	**$0**	**$30,568**	**$424,556**	**$244,544**	**$244,544**	**$244,544**	**$244,544**	**$244,544**	**$244,544**
Market LCFS Price	$/LCFS			$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26
LCFS Credits	$	0	0	4,552	45,926	26,274	26,158	26,041	26,041	26,041	26,041
Accrued LCFS Revenue	$	$0	$0	$292,515	$2,951,164	$1,688,333	$1,680,872	$1,673,352	$1,673,352	$1,673,352	$1,673,352
Total LCFS Revenue	$	**$0**	**$0**	**$0**	**$2,395,752**	**$1,692,093**	**$1,684,602**	**$1,677,112**	**$1,673,352**	**$1,673,352**	**$1,673,352**
D3 RINs	$	0	0	222,916	2,006,240	1,146,423	1,146,423	1,146,423	1,146,423	1,146,423	1,146,423
Market D3 RINS Price	$/RIN			$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92
Accrued D3 RINs Revenue	$	$0	$0	$378,956	$3,410,608	$1,948,919	$1,948,919	$1,948,919	$1,948,919	$1,948,919	$1,948,919
Total D3 RINS Revenue	$	**$0**	**$0**	**$243,615**	**$3,383,540**	**$1,948,919**	**$1,948,919**	**$1,948,919**	**$1,948,919**	**$1,948,919**	**$1,948,919**
Total Accrued Revenue	$	**$0**	**$0**	**$719,021**	**$6,789,724**	**$3,881,796**	**$3,874,335**	**$3,866,815**	**$3,866,815**	**$3,866,815**	**$3,866,815**
Total Cash Revenue		**$0**	**$0**	**$274,183**	**$6,203,848**	**$3,885,556**	**$3,878,066**	**$3,870,575**	**$3,866,815**	**$3,866,815**	**$3,866,815**
Gas Value	$/MMBtu		0.00	8.02	69.41	39.68	39.61	39.53	39.53	39.53	39.53
Operating Expenses											
Management Services & Labor	$	$0	($45,832)	($277,745)	($280,522)	($283,327)	($286,161)	($289,022)	($291,913)	($294,832)	($297,780)
Material Processing & Digestion	$	$0	($14,051)	($468,319)	($516,002)	($521,162)	($526,374)	($531,637)	($536,954)	($542,323)	($547,746)
Gas Conditioning & Compression	$	$0	($13,063)	($435,390)	($479,721)	($484,518)	($489,363)	($494,257)	($499,199)	($504,191)	($509,233)
Coarse Separation	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fine Solids Separation	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Water Treatment System	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fiber Drying	$	$0	($9,332)	($311,020)	($342,687)	($346,114)	($349,575)	($353,071)	($356,602)	($360,168)	($363,770)
Misc. Expenses		$0	($28,750)	($172,500)	($172,500)	($172,500)	($172,500)	($172,500)	($172,500)	($172,500)	($172,500)
Total Accrued Operating Expenses	$	**$0**	**($111,028)**	**($1,664,973)**	**($1,791,432)**	**($1,807,621)**	**($1,823,973)**	**($1,840,487)**	**($1,857,167)**	**($1,874,014)**	**($1,891,029)**
Total Cash Operating Expenses	$	**$0**	**($37,291)**	**($1,590,760)**	**($1,790,096)**	**($1,806,272)**	**($1,822,610)**	**($1,839,111)**	**($1,855,777)**	**($1,872,610)**	**($1,889,611)**
Depreciation											
Total Depreciation	$	**$0**	**($544,449)**	**($3,655,314)**	**($5,331,714)**	**($3,807,714)**	**($2,719,578)**	**($2,041,017)**	**($2,039,493)**	**($1,871,091)**	**($849,630)**

CASH FLOW											
Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenue	$	$0	$0	$719,021	$6,789,724	$3,881,796	$3,874,335	$3,866,815	$3,866,815	$3,866,815	$3,866,815
Operating Expenses	$	$0	($111,028)	($1,664,973)	($1,791,432)	($1,807,621)	($1,823,973)	($1,840,487)	($1,857,167)	($1,874,014)	($1,891,029)
Net Operating Income	$	**$0**	**($111,028)**	**($945,952)**	**$4,998,292**	**$2,074,174**	**$2,050,363**	**$2,026,327**	**$2,009,648**	**$1,992,801**	**$1,975,786**
Loan Interest Expense	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOI After Interest Expense	$	**$0**	**($111,028)**	**($945,952)**	**$4,998,292**	**$2,074,174**	**$2,050,363**	**$2,026,327**	**$2,009,648**	**$1,992,801**	**$1,975,786**
Depreciation	$	$0	($544,449)	($3,655,314)	($5,331,714)	($3,807,714)	($2,719,578)	($2,041,017)	($2,039,493)	($1,871,091)	($849,630)
Taxable Income	$	**$0**	**($655,477)**	**($4,601,266)**	**($333,422)**	**($1,733,540)**	**($669,215)**	**($14,690)**	**($29,845)**	**$121,710**	**$1,126,156**
Federal Tax Benefit / (Expense)	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
State Tax Benefit / (Expense)	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tax Benefit / (Expense)	$	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	**$0**	**($655,477)**	**($4,601,266)**	**($333,422)**	**($1,733,540)**	**($669,215)**	**($14,690)**	**($29,845)**	**$121,710**	**$1,126,156**
Project-Level Cash Flow											
Equity Contribution	$	**($5,597,500)**	**($17,262,500)**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	$0	($655,477)	($4,601,266)	($333,422)	($1,733,540)	($669,215)	($14,690)	($29,845)	$121,710	$1,126,156
Non Cash Adjustments	$	$0	$544,449	$3,655,314	$5,331,714	$3,807,714	$2,719,578	$2,041,017	$2,039,493	$1,871,091	$849,630
Change in Net Working Capital	$	$0	$73,737	($370,625)	($584,541)	$5,109	$5,093	$5,136	$1,390	$1,404	$1,418
Working Capital Reserve Release		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ITC Transfer Proceeds		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operating Cash Flow	$	**$0**	**($37,291)**	**($1,316,577)**	**$4,413,751**	**$2,079,284**	**$2,055,456**	**$2,031,464**	**$2,011,038**	**$1,994,205**	**$1,977,204**
Net Cash Flow	$	**($5,597,500)**	**($17,299,791)**	**($1,316,577)**	**$4,413,751**	**$2,079,284**	**$2,055,456**	**$2,031,464**	**$2,011,038**	**$1,994,205**	**$1,977,204**

Table 6.8.5: Proforma– Base Case – Farm F

ANNUAL PROFORMA	Operating Year / Year	1 / 2024	2 / 2025	3 / 2026	4 / 2027	5 / 2028	6 / 2029	7 / 2030	8 / 2031	9 / 2032	10 / 2033
OPERATING MODEL											
Renewable Natural Gas Generation											
Gas Generated	MMBtu	6,190	37,138	37,138	37,138	37,138	37,138	37,138	37,138	37,138	37,138
Ramp Up Rate	%	0%	3%	92%	100%	100%	100%	100%	100%	100%	100%
Net Gas Generation	MMBtu	**0**	**1,032**	**34,043**	**37,138**	**37,138**	**37,138**	**37,138**	**37,138**	**37,138**	**37,138**
Gas Released from Storage		**0**	**0**	**7,221**	**64,992**	**37,138**	**37,138**	**37,138**	**37,138**	**37,138**	**37,138**
Revenue											
Gas Price	$/MMBtu			$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Accrued Gas Revenue	$	$0	$0	$18,053	$162,479	$92,845	$92,845	$92,845	$92,845	$92,845	$92,845
Gas Revenue Received	$	**$0**	**$0**	**$11,606**	**$161,190**	**$92,845**	**$92,845**	**$92,845**	**$92,845**	**$92,845**	**$92,845**
Market LCFS Price	$/LCFS			$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26
LCFS Credits	$	0	0	1,728	17,437	9,975	9,931	9,887	9,887	9,887	9,887
Accrued LCFS Revenue	$	$0	$0	$111,058	$1,120,457	$641,003	$638,170	$635,315	$635,315	$635,315	$635,315
Total LCFS Revenue	$	**$0**	**$0**	**$0**	**$909,586**	**$642,431**	**$639,587**	**$636,743**	**$635,315**	**$635,315**	**$635,315**
D3 RINs	$	0	0	84,634	761,702	435,258	435,258	435,258	435,258	435,258	435,258
Market D3 RINS Price	$/RIN			$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92	$19.92
Accrued D3 RINs Revenue	$	$0	$0	$143,877	$1,294,893	$739,939	$739,939	$739,939	$739,939	$739,939	$739,939
Total D3 RINS Revenue	$	**$0**	**$0**	**$92,492**	**$1,284,616**	**$739,939**	**$739,939**	**$739,939**	**$739,939**	**$739,939**	**$739,939**
Total Accrued Revenue	$	**$0**	**$0**	**$272,988**	**$2,577,830**	**$1,473,787**	**$1,470,955**	**$1,468,099**	**$1,468,099**	**$1,468,099**	**$1,468,099**
Total Cash Revenue		**$0**	**$0**	**$104,098**	**$2,355,392**	**$1,475,215**	**$1,472,371**	**$1,469,527**	**$1,468,099**	**$1,468,099**	**$1,468,099**
Gas Value	$/MMBtu		0.00	8.02	69.41	39.68	39.61	39.53	39.53	39.53	39.53
Operating Expenses											
Management Services & Labor	$	$0	($33,064)	($200,371)	($202,374)	($204,398)	($206,442)	($208,507)	($210,592)	($212,698)	($214,824)
Material Processing & Digestion	$	$0	($5,335)	($177,805)	($195,909)	($197,868)	($199,846)	($201,845)	($203,863)	($205,902)	($207,961)
Gas Conditioning & Compression	$	$0	($4,960)	($165,303)	($182,134)	($183,955)	($185,795)	($187,653)	($189,529)	($191,424)	($193,339)
Coarse Separation	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fine Solids Separation	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Water Treatment System	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fiber Drying	$	$0	($7,280)	($242,650)	($267,356)	($270,030)	($272,730)	($275,457)	($278,212)	($280,994)	($283,804)
Misc. Expenses		$0	($17,917)	($107,500)	($107,500)	($107,500)	($107,500)	($107,500)	($107,500)	($107,500)	($107,500)
Total Accrued Operating Expenses	$	**$0**	**($68,556)**	**($893,629)**	**($955,273)**	**($963,751)**	**($972,313)**	**($980,961)**	**($989,696)**	**($998,518)**	**($1,007,428)**
Total Cash Operating Expenses	$	**$0**	**($25,491)**	**($857,787)**	**($954,574)**	**($963,044)**	**($971,600)**	**($980,241)**	**($988,968)**	**($997,783)**	**($1,006,686)**
Depreciation											
Total Depreciation	$	**$0**	**($464,187)**	**($3,116,451)**	**($4,545,718)**	**($3,246,384)**	**($2,318,660)**	**($1,740,132)**	**($1,738,833)**	**($1,595,257)**	**($724,378)**
CASH FLOW											
Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenue	$	$0	$0	$272,988	$2,577,830	$1,473,787	$1,470,955	$1,468,099	$1,468,099	$1,468,099	$1,468,099
Operating Expenses	$	$0	($68,556)	($893,629)	($955,273)	($963,751)	($972,313)	($980,961)	($989,696)	($998,518)	($1,007,428)
Net Operating Income	$	**$0**	**($68,556)**	**($620,640)**	**$1,622,557**	**$510,036**	**$498,641**	**$487,138**	**$478,403**	**$469,581**	**$460,671**
Loan Interest Expense	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOI After Interest Expense	$	**$0**	**($68,556)**	**($620,640)**	**$1,622,557**	**$510,036**	**$498,641**	**$487,138**	**$478,403**	**$469,581**	**$460,671**
Depreciation	$	$0	($464,187)	($3,116,451)	($4,545,718)	($3,246,384)	($2,318,660)	($1,740,132)	($1,738,833)	($1,595,257)	($724,378)
Taxable Income	$	**$0**	**($532,742)**	**($3,737,091)**	**($2,923,161)**	**($2,736,348)**	**($1,820,019)**	**($1,252,994)**	**($1,260,430)**	**($1,125,675)**	**($263,707)**
Federal Tax Benefit / (Expense)	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
State Tax Benefit / (Expense)	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tax Benefit / (Expense)	$	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	**$0**	**($532,742)**	**($3,737,091)**	**($2,923,161)**	**($2,736,348)**	**($1,820,019)**	**($1,252,994)**	**($1,260,430)**	**($1,125,675)**	**($263,707)**
Project-Level Cash Flow											
Equity Contribution	$	**($4,515,000)**	**($14,975,000)**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	$0	($532,742)	($3,737,091)	($2,923,161)	($2,736,348)	($1,820,019)	($1,252,994)	($1,260,430)	($1,125,675)	($263,707)
Non Cash Adjustments	$	$0	$464,187	$3,116,451	$4,545,718	$3,246,384	$2,318,660	$1,740,132	$1,738,833	$1,595,257	$724,378
Change in Net Working Capital	$	$0	$43,065	($133,049)	($221,738)	$2,134	$2,130	$2,148	$728	$735	$743
Working Capital Reserve Release		$0	$0	$0	$20,415	$87,311	$56,849	$0	$0	$0	$0
ITC Transfer Proceeds		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operating Cash Flow	$	**$0**	**($25,491)**	**($753,689)**	**$1,421,233**	**$599,482**	**$557,620**	**$489,286**	**$479,131**	**$470,317**	**$461,414**
Net Cash Flow	$	**($4,515,000)**	**($15,000,491)**	**($753,689)**	**$1,421,233**	**$599,482**	**$557,620**	**$489,286**	**$479,131**	**$470,317**	**$461,414**

Table 6.8.6: Proforma– Cluster Base Case

ANNUAL PROFORMA	Operating Year / Year	1 2024	2 2025	3 2026	4 2027	5 2028	6 2029	7 2030	8 2031	9 2032	10 2033
OPERATING MODEL											
Renewable Natural Gas Generation											
Gas Generated	MMBtu	89,902	134,852	134,852	134,852	134,852	134,852	134,852	134,852	134,852	134,852
Ramp Up Rate	%	0%	4%	92%	100%	100%	100%	100%	100%	100%	100%
Net Gas Generation	MMBtu	**0**	**5,619**	**123,615**	**134,852**	**134,852**	**134,852**	**134,852**	**134,852**	**134,852**	**134,852**
Gas Released from Storage		**0**	**0**	**28,094**	**235,991**	**134,852**	**134,852**	**134,852**	**134,852**	**134,852**	**134,852**
Revenue											
Gas Price	$/MMBtu			$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Accrued Gas Revenue	$	$0	$0	$70,236	$589,979	$337,131	$337,131	$337,131	$337,131	$337,131	$337,131
Gas Revenue Received	$	**$0**	**$0**	**$46,824**	**$585,296**	**$337,131**	**$337,131**	**$337,131**	**$337,131**	**$337,131**	**$337,131**
Market LCFS Price	$/LCFS			$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26	$64.26
LCFS Credits	$	0	0	6,072	65,737	37,847	37,702	37,557	37,557	37,557	37,557
Accrued LCFS Revenue	$	$0	$0	$390,161	$4,224,286	$2,432,035	$2,422,747	$2,413,385	$2,413,385	$2,413,385	$2,413,385
Total LCFS Revenue	$	**$0**	**$0**	**$0**	**$3,393,749**	**$2,436,716**	**$2,427,391**	**$2,418,066**	**$2,413,385**	**$2,413,385**	**$2,413,385**
D3 RINs	$	0	0	329,264	2,765,820	1,580,469	1,580,469	1,580,469	1,580,469	1,580,469	1,580,469
Market D3 RINS Price	$/RIN			$19.49	$19.49	$19.49	$19.49	$19.49	$19.49	$19.49	$19.49
Accrued D3 RINs Revenue	$	$0	$0	$547,632	$4,600,112	$2,628,635	$2,628,635	$2,628,635	$2,628,635	$2,628,635	$2,628,635
Total D3 RINS Revenue	$	**$0**	**$0**	**$365,088**	**$4,563,603**	**$2,628,635**	**$2,628,635**	**$2,628,635**	**$2,628,635**	**$2,628,635**	**$2,628,635**
Total Accrued Revenue	$	**$0**	**$0**	**$1,008,029**	**$9,414,376**	**$5,397,801**	**$5,388,513**	**$5,379,151**	**$5,379,151**	**$5,379,151**	**$5,379,151**
Total Cash Revenue		**$0**	**$0**	**$411,912**	**$8,542,648**	**$5,402,482**	**$5,393,157**	**$5,383,832**	**$5,379,151**	**$5,379,151**	**$5,379,151**
Gas Value	$/MMBtu		0.00	8.15	69.81	40.03	39.96	39.89	39.89	39.89	39.89
Operating Expenses											
Management Services & Labor	$	$0	($39,438)	($477,983)	($482,763)	($487,591)	($492,467)	($497,392)	($502,365)	($507,389)	($512,463)
Material Processing & Digestion	$	$0	($25,424)	($564,925)	($622,444)	($628,669)	($634,955)	($641,305)	($647,718)	($654,195)	($660,737)
Gas Conditioning & Compression	$	$0	($31,496)	($699,851)	($771,108)	($778,819)	($786,608)	($794,474)	($802,418)	($810,443)	($818,547)
Fiber Separation	$	$0	($5,675)	($126,099)	($138,938)	($140,328)	($141,731)	($143,148)	($144,580)	($146,026)	($147,486)
Water Treatment System	$	$0	($36,498)	($810,996)	($893,571)	($902,506)	($911,531)	($920,647)	($929,853)	($939,152)	($948,543)
Fiber Drying	$	$0	($16,874)	($374,951)	($413,128)	($417,259)	($421,432)	($425,646)	($429,903)	($434,202)	($438,544)
Misc. Expenses		$0	($27,083)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)
Total Accrued Operating Expenses	$	**$0**	**($182,490)**	**($3,379,806)**	**($3,646,953)**	**($3,680,172)**	**($3,713,724)**	**($3,747,611)**	**($3,781,837)**	**($3,816,406)**	**($3,851,320)**
Total Cash Operating Expenses	$	**$0**	**($38,656)**	**($3,222,467)**	**($3,644,212)**	**($3,677,404)**	**($3,710,928)**	**($3,744,787)**	**($3,778,985)**	**($3,813,525)**	**($3,848,410)**
Depreciation											
Total Depreciation	$	**$0**	**($510,368)**	**($6,488,708)**	**($10,245,930)**	**($7,317,297)**	**($5,225,825)**	**($3,826,866)**	**($3,823,295)**	**($3,667,577)**	**($1,752,180)**
CASH FLOW											
Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenue	$	$0	$0	$1,008,029	$9,414,376	$5,397,801	$5,388,513	$5,379,151	$5,379,151	$5,379,151	$5,379,151
Operating Expenses	$	$0	($182,490)	($3,379,806)	($3,646,953)	($3,680,172)	($3,713,724)	($3,747,611)	($3,781,837)	($3,816,406)	($3,851,320)
Net Operating Income	$	**$0**	**($182,490)**	**($2,371,776)**	**$5,767,424**	**$1,717,629**	**$1,674,789**	**$1,631,540**	**$1,597,314**	**$1,562,745**	**$1,527,831**
Loan Interest Expense	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOI After Interest Expense	$	**$0**	**($182,490)**	**($2,371,776)**	**$5,767,424**	**$1,717,629**	**$1,674,789**	**$1,631,540**	**$1,597,314**	**$1,562,745**	**$1,527,831**
Depreciation	$	$0	($510,368)	($6,488,708)	($10,245,930)	($7,317,297)	($5,225,825)	($3,826,866)	($3,823,295)	($3,667,577)	($1,752,180)
Taxable Income	$	**$0**	**($692,857)**	**($8,860,485)**	**($4,478,507)**	**($5,599,668)**	**($3,551,035)**	**($2,195,327)**	**($2,225,981)**	**($2,104,832)**	**($224,349)**
Federal Tax Benefit / (Expense)	$	$0	$145,500	$1,860,702	$940,486	$1,175,930	$745,717	$461,019	$467,456	$442,015	$47,113
State Tax Benefit / (Expense)	$	$0	$54,736	$699,978	$353,802	$442,374	$280,532	$173,431	$175,853	$166,282	$17,724
Total Tax Benefit / (Expense)	$	**$0**	**$200,236**	**$2,560,680**	**$1,294,288**	**$1,618,304**	**$1,026,249**	**$634,449**	**$643,309**	**$608,296**	**$64,837**
Net Income	$	**$0**	**($492,622)**	**($6,299,804)**	**($3,184,218)**	**($3,981,364)**	**($2,524,786)**	**($1,560,877)**	**($1,582,673)**	**($1,496,536)**	**($159,512)**
Project-Level Cash Flow											
Equity Contribution	$	**($26,871,996)**	**($15,986,052)**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	$0	($492,622)	($6,299,804)	($3,184,218)	($3,981,364)	($2,524,786)	($1,560,877)	($1,582,673)	($1,496,536)	($159,512)
Non Cash Adjustments	$	$0	$510,368	$6,488,708	$10,245,930	$7,317,297	$5,225,825	$3,826,866	$3,823,295	$3,667,577	$1,752,180
Change in Net Working Capital	$	$0	$143,833	($438,779)	($868,987)	$7,449	$7,440	$7,505	$2,852	$2,881	$2,910
Working Capital Reserve Release		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ITC Transfer Proceeds		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operating Cash Flow	$	**$0**	**$161,580**	**($249,875)**	**$6,192,725**	**$3,343,382**	**$2,708,478**	**$2,273,494**	**$2,243,474**	**$2,173,923**	**$1,595,578**
Net Cash Flow	$	**($26,871,996)**	**($15,824,472)**	**($249,875)**	**$6,192,725**	**$3,343,382**	**$2,708,478**	**$2,273,494**	**$2,243,474**	**$2,173,923**	**$1,595,578**

Table 6.8.7: Proforma – Cluster Upside - 40% ITC and $1.3 million in grant funding - $65/MMBtu gas

ANNUAL PROFORMA	Operating Year Year	1 2024	2 2025	3 2026	4 2027	5 2028	6 2029	7 2030	8 2031	9 2032	10 2033
OPERATING MODEL											
Renewable Natural Gas Generation											
Gas Generated	MMBtu	96,505	144,757	144,757	144,757	144,757	144,757	144,757	144,757	144,757	144,757
Ramp Up Rate	%	0%	4%	92%	100%	100%	100%	100%	100%	100%	100%
Net Gas Generation	MMBtu	**0**	**6,032**	**132,694**	**144,757**	**144,757**	**144,757**	**144,757**	**144,757**	**144,757**	**144,757**
Gas Released from Storage		**0**	**0**	**30,158**	**253,325**	**144,757**	**144,757**	**144,757**	**144,757**	**144,757**	**144,757**
Revenue											
Gas Price	$/MMBtu			$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Accrued Gas Revenue	$	$0	$0	$75,394	$633,313	$361,893	$361,893	$361,893	$361,893	$361,893	$361,893
Gas Revenue Received	$	**$0**	**$0**	**$50,263**	**$628,286**	**$361,893**	**$361,893**	**$361,893**	**$361,893**	**$361,893**	**$361,893**
Market LCFS Price	$/LCFS			$139.86	$139.86	$139.86	$139.86	$139.86	$139.86	$139.86	$139.86
LCFS Credits	$	0	0	6,518	70,566	40,627	40,472	40,315	40,315	40,315	40,315
Accrued LCFS Revenue	$	$0	$0	$911,547	$9,869,339	$5,682,044	$5,660,344	$5,638,471	$5,638,471	$5,638,471	$5,638,471
Total LCFS Revenue	$	**$0**	**$0**	**$0**	**$7,928,927**	**$5,692,980**	**$5,671,194**	**$5,649,408**	**$5,638,471**	**$5,638,471**	**$5,638,471**
D3 RINs	$	0	0	353,449	2,968,970	1,696,554	1,696,554	1,696,554	1,696,554	1,696,554	1,696,554
Market D3 RINS Price	$/RIN			$23.48	$23.48	$23.48	$23.48	$23.48	$23.48	$23.48	$23.48
Accrued D3 RINs Revenue	$	$0	$0	$708,099	$5,948,035	$3,398,877	$3,398,877	$3,398,877	$3,398,877	$3,398,877	$3,398,877
Total D3 RINS Revenue	$	**$0**	**$0**	**$472,066**	**$5,900,828**	**$3,398,877**	**$3,398,877**	**$3,398,877**	**$3,398,877**	**$3,398,877**	**$3,398,877**
Total Accrued Revenue	$	**$0**	**$0**	**$1,695,041**	**$16,450,686**	**$9,442,814**	**$9,421,114**	**$9,399,241**	**$9,399,241**	**$9,399,241**	**$9,399,241**
Total Cash Revenue		**$0**	**$0**	**$522,329**	**$14,458,042**	**$9,453,750**	**$9,431,964**	**$9,410,178**	**$9,399,241**	**$9,399,241**	**$9,399,241**
Gas Value	$/MMBtu		0.00	12.77	113.64	65.23	65.08	64.93	64.93	64.93	64.93
Operating Expenses											
Management Services & Labor	$	$0	($40,480)	($490,614)	($495,520)	($500,475)	($505,480)	($510,534)	($515,640)	($520,796)	($526,004)
Material Processing & Digestion	$	$0	($27,292)	($606,418)	($668,163)	($674,844)	($681,593)	($688,409)	($695,293)	($702,246)	($709,268)
Gas Conditioning & Compression	$	$0	($33,810)	($751,255)	($827,746)	($836,024)	($844,384)	($852,828)	($861,356)	($869,970)	($878,669)
Fiber Separation	$	$0	($6,092)	($135,361)	($149,143)	($150,635)	($152,141)	($153,663)	($155,199)	($156,751)	($158,319)
Water Treatment System	$	$0	($32,086)	($712,960)	($785,553)	($793,408)	($801,342)	($809,356)	($817,449)	($825,624)	($833,880)
Fiber Drying	$	$0	($16,874)	($374,951)	($413,128)	($417,259)	($421,432)	($425,646)	($429,903)	($434,202)	($438,544)
Misc. Expenses		$0	($27,083)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)	($325,000)
Total Accrued Operating Expenses	$	**$0**	**($183,717)**	**($3,396,560)**	**($3,664,253)**	**($3,697,646)**	**($3,731,372)**	**($3,765,436)**	**($3,799,840)**	**($3,834,589)**	**($3,869,685)**
Total Cash Operating Expenses	$	**$0**	**($38,718)**	**($3,238,960)**	**($3,661,498)**	**($3,694,863)**	**($3,728,562)**	**($3,762,597)**	**($3,796,973)**	**($3,831,693)**	**($3,866,760)**
Depreciation											
Total Depreciation	$	**$0**	**($500,609)**	**($6,364,642)**	**($10,050,025)**	**($7,177,388)**	**($5,125,905)**	**($3,753,695)**	**($3,750,192)**	**($3,597,452)**	**($1,718,678)**

CASH FLOW											
Income Statement		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Revenue	$	$0	$0	$1,695,041	$16,450,686	$9,442,814	$9,421,114	$9,399,241	$9,399,241	$9,399,241	$9,399,241
Operating Expenses	$	$0	($183,717)	($3,396,560)	($3,664,253)	($3,697,646)	($3,731,372)	($3,765,436)	($3,799,840)	($3,834,589)	($3,869,685)
Net Operating Income	$	**$0**	**($183,717)**	**($1,701,519)**	**$12,786,433**	**$5,745,168**	**$5,689,742**	**$5,633,805**	**$5,599,401**	**$5,564,653**	**$5,529,557**
Loan Interest Expense	$	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOI After Interest Expense	$	**$0**	**($183,717)**	**($1,701,519)**	**$12,786,433**	**$5,745,168**	**$5,689,742**	**$5,633,805**	**$5,599,401**	**$5,564,653**	**$5,529,557**
Depreciation	$	$0	($500,609)	($6,364,642)	($10,050,025)	($7,177,388)	($5,125,905)	($3,753,695)	($3,750,192)	($3,597,452)	($1,718,678)
Taxable Income	$	**$0**	**($684,327)**	**($8,066,161)**	**$2,736,409**	**($1,432,220)**	**$563,837**	**$1,880,110**	**$1,849,209**	**$1,967,201**	**$3,810,879**
Federal Tax Benefit / (Expense)	$	$0	$143,709	$1,693,894	($574,646)	$300,766	($118,406)	($394,823)	($388,334)	($413,112)	($800,285)
State Tax Benefit / (Expense)	$	$0	$54,062	$637,227	($216,176)	$113,145	($44,543)	($148,529)	($146,088)	($155,409)	($301,059)
Total Tax Benefit / (Expense)	$	**$0**	**$197,770**	**$2,331,120**	**($790,822)**	**$413,912**	**($162,949)**	**($543,352)**	**($534,421)**	**($568,521)**	**($1,101,344)**
Net Income	$	**$0**	**($486,556)**	**($5,735,040)**	**$1,945,586**	**($1,018,308)**	**$400,888**	**$1,336,758**	**$1,314,788**	**$1,398,680**	**$2,709,535**
Project-Level Cash Flow											
Equity Contribution	$	**($26,625,925)**	**($15,412,661)**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income	$	$0	($486,556)	($5,735,040)	$1,945,586	($1,018,308)	$400,888	$1,336,758	$1,314,788	$1,398,680	$2,709,535
Non Cash Adjustments	$	$0	$500,609	$6,364,642	$10,050,025	$7,177,388	$5,125,905	$3,753,695	$3,750,192	$3,597,452	$1,718,678
Change in Net Working Capital	$	$0	$144,999	($1,015,112)	($1,989,889)	$13,719	$13,660	$13,775	$2,867	$2,896	$2,925
Working Capital Reserve Release		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ITC Transfer Proceeds		$0	$15,133,891	$0	$0	$0	$0	$0	$0	$0	$0
Operating Cash Flow	$	**$0**	**$15,292,943**	**($385,510)**	**$10,005,722**	**$6,172,799**	**$5,540,454**	**$5,104,229**	**$5,067,847**	**$4,999,027**	**$4,431,137**
Net Cash Flow	$	**($26,625,925)**	**($119,718)**	**($385,510)**	**$10,005,722**	**$6,172,799**	**$5,540,454**	**$5,104,229**	**$5,067,847**	**$4,999,027**	**$4,431,137**

6.9 Economic Scalability

Based on the preliminary modeling, it takes a single farm with a herd size of about 2,500 wet cow equivalents (WCE) to be economically viable. In the cluster identified, there is one farm that could install a digester system that is economically viable. By adding in the infrastructure for a community-based system, there needs to be about 5,000 WCE within a 5 mile radius of the project site to be economically feasible, which is the size of the participants in the cluster identified. Scaling to other parts of the county, there needs to be clusters of at least 5,000 WCE within 5 miles of the project site or at least 10,000 WCE within a 10 mile radius of the project site.

7.0 Project Development

7.1 Permitting

The two critical path permits for this project are the Wisconsin Pollutant Discharge Elimination System (WPDES) permit and the air permit. The WPDES permit and the air permit require significant modeling and detailing of the process during the application process. Based on feedback from the DNR, it will take approximately 6 months from the time of application acceptance to the receipt of these permits.

As part of the WPDES permitting process, the project will require a water quality trading plan in order to discharge into produced waster. Trading partners will need to be identified and contracts between all the parties will need to be in place prior to finalizing a draft of the WPDES permit.

The project will also require a storm water permit, wetland permit, and pipeline permit. These will require a majority of the civil engineering to be completed prior to submitting the application in addition to wetland delineation reports and screening for archaeological, historical, and endangered or threatened resources.

This project will also require modifications to the WPDES permits of the participating farms as it impacts their nutrient management plans and manure handling plans. Any non-permitted farms that are part of the project will be required to have a nutrient management plan in place and the reporting will go through the WPDES permit of the project.

As part of the WPDES process, if the plant desires to obtain a discharge for the water produced by the system, it will need to take additional steps to mitigate the added amounts of phosphorus and suspended solids in the water if the receiving stream is subject to a Total Maximum Daily Load (TMDL). Typically, the project will need to install adaptive management practices to offset any added load to the receiving water.

Also, as part of the WPDES process, the plant may be able to generate phosphorus and total suspended solids credits by exporting nutrients from the watershed and working with the participating farms to adjust their tillage practices. Typically, these credits are generated by using the farm’s existing manure application plan, tillage practices, and crop rotation as the baseline and then measuring the changes due to the new system. These credits can take years to aggregate and verify. Once the credits are created, the next step in the process is to identify a potential trading partner in the same watershed that needs to reduce their loading. Typical trading partners have a point source discharge in the same receiving water as the project and are either a municipal wastewater treatment facility or an industrial facility that has its own wastewater treatment system with a discharge. The trading partner will determine the value of the credits based on their alternate means of acquiring credits. The challenge is establishing credit pricing that is economically beneficial to both parties.

Finally, the project will require manure storage permits and possibly shoreland zoning permits depending on the project location at the county level and may require a conditional use permit and roadway utility easements for the pipelines from the town.

7.2 Project Ownership

There are many potential ownership structures for community digestion systems. Below is a brief discussion of some of the more common structures.

7.2.1 Individual Farm Ownership

In this ownership structure, each farm owns and operates the assets related to the project that are installed on their farm. This structure could work if each farm had their own independent system and possibly a joint interconnect system. This structure is not common in true community-based systems due to the multiple assets that are processing the manure and biogas from multiple farms.

7.2.2 Farm Group Ownership

In this structure, the participating farms would form a joint venture or co-operative. The farms would invest the required equity needed to build the project and would cover the operating expenses as needed. This is similar to the concept used in the ethanol industry about 20 years ago. Again, this structure is not common for community-based systems.

7.2.3 Private Third-Party Ownership

In this structure, a third-party investor would supply the necessary capital and operating expenses and have ownership of the facility. This is one of the most common structures currently in the market. The participating farms typically have a direct or indirect financial compensation structure for participating, but do not have ownership of the facility. These companies are also in a position to take advantage of the tax incentives that are currently available where most farms have minimal federal tax liabilities.

Recently, there have been projects developed that have both farm ownership and third-party ownership in which they both share in the benefits and risks of the project and can take advantage of the federal programs. In most cases, the third-party investor has the controlling interest in the project.

7.2.4 Public Ownership

In this structure, a public entity would own and operate the facility. This was the structure for the IEUA project in California. The advantage of public ownership is typically a lower return expectation and long-term stability. One of the challenges with public ownership is navigating the internal processes to allow for selection of an engineering firm, construction firm, and operating firm that has experience in this field and may not necessarily be the lowest cost provider. Another challenge is purchasing parts and services for the project following an unexpected outage through the existing purchasing system and requirements. To overcome this challenge, most government operated facilities have significantly higher inventory levels than a typical facility. One of the main economic drivers currently are the investment and production tax credits. Since most government agencies do not have a federal tax liability, utilizing these tax credits is a challenge.

7.2.5 Public-Private Partnership

This structure has been used by a couple community-based systems. In past projects, the public entity owned and operated a portion of the project and a private entity owned and operated another portion of the project. This structure works well when the full system is operating as intended but can create significant challenges when one of the parties is not performing to expectations since both suffer economically. This structure is helpful in incentivizing a third party to invest by lowering the overall capital investment allowing them to obtain their desired return levels. This structure also allows the private party to take advantage of the tax incentives generated by the project. The key to making this structure work is clearly defining the relationship between both parties, the governance structure, and the consequences for lack of performance.

7.3 Next Steps for Development

One of the keys for the development of this project will be to locate an RNG off-taker that can provide pricing for the gas that meets the requirements of the project investor.

Once this is in place, the next steps in the development of this project include securing feedstock contracts with the participating farms, selecting a site, beginning project engineering and permitting, and securing an interconnection agreement with one of the pipeline companies.

As the engineering of the project progresses, meetings with the project partners and the community will be needed to ensure the plant meets the needs of the project partners and fits within the objectives of the local community. A construction partner will also be required to finalize the project budget and schedule.

Once the permits are in place, all contractual agreements are in place, and the construction budget and schedule continue to meet the expectations of the project owners, the project should achieve financial closure.

8.0 Conclusion

In summary, our findings indicate that the integration of anaerobic digestion with the production of renewable natural gas along with advanced nutrient separation can be accomplished in Washington County. In order to be economically feasible, the project will require a gas off-take that exceeds current market pricing or an investor willing to hedge that future pricing will be higher than current market pricing. Given the numerous environmental and sustainability aspects of this type of project, the challenge will be finding an investor that appreciates these aspects and can place a value on them to move this project forward.

If this project simply produced renewable natural gas and didn't incur the cost of the effluent management system, the feasibility of the project is greatly improved. The financial burden of covering the operating cost of both the gas production equipment and the effluent clean up equipment makes the feasibility much more challenging. Additional sources of revenue may also need to be identified or the business model may require the farms to pay a portion of the operating costs for the effluent management system.