The Renewable Energy Opportunity in Duplin County

Biogas Production from Hog Waste

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8/20/2014
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Executive Summary

As concerns about climate change and energy independence grow, biogas production is a promising technology that captures energy from the breakdown of organic wastes. North Carolina, and Duplin County specifically, is well positioned to attract this industry, as it has an abundance of agricultural residue, manure, and food processing waste that can serve as fuel for biogas production. That biogas can then be burned to generate electricity, or processed into natural gas or compressed natural gas (CNG) vehicle fuel.

Biogas production has become a staple of European renewable energy technology, but is still fairly new in North America. Small-scale systems have begun to proliferate over the past decade, particularly on dairy farms. Increasingly, there is a trend to construct large biogas plants that centralize multiple waste streams to improve efficiency and profitability.

This report was undertaken in response to a recent proposal for such a centralized biogas plant in Duplin County, with the goal of providing detailed information on a plant’s operations, its potential impacts, appropriate mitigation techniques, and alternatives. Data for this report was gathered by examining fifteen centralized biogas plants across the country through phone interviews, web-based research and academic literature.

A common community concern surrounding biogas plants is their potential odor. This report finds that while there will be some odor from the plant – 3 to 4 days a year at a well-run facility – overall, the plant will contribute to a reduction of odors in the area. Producing biogas involves the breakdown of raw waste materials and through this process the waste loses much of its odor. At the end of the production process an effluent is left behind that has reduced odor and pathogens and has high value as a fertilizer. As this effluent is used as an alternative to raw manure for field application, and raw manure thus no longer needs to be stored for extended periods, odors will be decreased on participating farms.

Biogas plants are integrated systems that require a tight balance between the waste products available locally and the local need for liquid fertilizer. In Duplin County’s case, the plant must be designed to accept hog waste and provide value to farmers so that they will participate as waste providers. There must also be a productive use of the effluent as fertilizer or this product will become nothing more than a waste product in itself, albeit more inert than the original raw waste.

Biogas production is about improved waste management as much as renewable energy production. It captures value from a waste stream while also cleaning up that waste stream, upgrading it to a more usable form. From an economic development standpoint, it creates new job opportunities in an industry with potential for growth and improves local environmental quality for residents and businesses. Encouraging the growth of this industry can be done through work with stakeholders to increase community awareness and by creating a workgroup to simplify the regulatory process.
At the request of the Duplin County Economic Development Director James Wolfe, this report outlines the opportunities and challenges of a centralized swine waste biogas facility. The report is organized to roughly follow the flow operations of a biogas plant, beginning with the collection of waste materials, proceeding through the biogas plant to the resulting revenue-generating products and effluent. At each stage the process and technology is described and potential issues and solutions are explored through case study examples.

This report focuses on a centralized configuration of biogas production, involving the transportation of waste materials from multiple sources to a single industrial site. Other system configurations are mentioned throughout the report and are catalogued in the final section. Fifteen case studies of centralized biogas plants across the country were considered in developing this report. Data on these plants were gathered through phone interviews, web-based research and academic literature.

The Biogas Opportunity in Duplin County, NC

Biogas is an energy-rich gaseous mixture of methane and carbon dioxide that is produced during the breakdown of organic waste. Energy production from organic wastes is a growing opportunity as concerns about climate change and the need for renewable energy sources grow. North Carolina’s 2007 Renewable Energy Portfolio Standard (REPS) is evidence of this trend. The REPS legislation mandates that utilities supply 12.5% of their electricity sales from renewable sources, including swine waste, by 2021. As a result, nine relatively small-scale biogas systems have been installed on swine farms, but to date there have been no large-scale centralized facilities fueled by swine waste established in North Carolina.

Nationwide, North Carolina has been recognized by the Union of Concerned Scientists as being among the top ten states for the availability of agricultural residues and manure that could be used as fuel for biogas production. Duplin County, as the top hog producing county in the state, is particularly well positioned to attract this growing biogas industry. If the waste from the approximately 2.3 million hogs in the county were captured and efficiently processed into biogas, it could power 10,000 homes. This opportunity is also evidenced by Novi Energy’s proposal for a centralized swine waste biogas plant, as well as other proposals that have come to the county.

From an economic development standpoint, the construction and operation of a large biogas plant would create around 80 temporary jobs and 20 permanent jobs based on previous examples around the country. The establishment of these plants creates the opportunity to attract complementary firms involved in the design and maintenance of such facilities. There is also precedent for developing a community college curriculum in electrical engineering and biology that supports the biogas industry, while also being applicable to other industries, thus benefiting both the industry and the local workforce.

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1 Author’s calculation. Assumes average home energy use of 12,069 kWh/year (http://www.epa.gov/greenpower/pubs/calcmeth.htm)
Renewable energy production, greenhouse gas capture, and green jobs are just part of the potential benefit from a biogas plant. This system of waste processing would also lower the odor profile of participating farms, and produce an effluent with high nutrient quality for use as fertilizer. These plants do not come without concerns however, and must be carefully planned and designed in order to minimize community impacts and ensure that all parties benefit. These are the challenges that this report seeks to address.

**Biogas Production**

The production of biogas entails capturing gasses released as organic materials decompose. The process at base is quite simple and has been applied around the country to generate electricity and natural gas from waste streams, including pre- and post-consumer food waste, wastewater, livestock manure, yard waste, and landfill waste. The bacteria that break down these materials thrive in an environment without oxygen, and thus the process is termed “anaerobic digestion.” As these bacteria digest organic materials, they release a mixture of methane gas, carbon dioxide, and other gasses, which make up the biogas. The methane is the most energy rich portion, ideally accounting for about 60% of the biogas. If this decomposition process is contained in a digester unit, these gasses can be captured and turned into energy rich outputs: electricity, natural gas, or compressed natural gas vehicle fuel (CNG).

Typically, biogas producing systems have four main components: a receiving area for preparing the waste materials, an enclosed ‘digester’ where an oxygen-free environment is maintained, a scrubber for purifying the biogas, and a generator for burning the biogas to make electricity. To produce natural gas or CNG, the generator would be replaced by equipment to further purify and compress the gas.

*Figure 1. Biogas System Configuration: System Input and Output Options.*

These systems can be scaled to suit many locations. On-farm digesters have become more common in recent years on dairy and hog farms. This report, however, is concerned primarily with centralized digesters which combine wastes from multiple farms and other sources. Centralizing waste streams in this way has a number of benefits. It makes the process more efficient and brings down the per-unit cost of producing electricity, and it allows smaller farms, for whom installing an on-farm digester is not cost effective, to participate. It also brings up issues, such as the transportation of wastes, that on-farm installations do not have to deal with.

**Waste Materials**

Though many organic materials can be fed into a digester, their energy content varies (see Figure 1). Manure is comparatively a low value material, but it has the advantage of being consistently available in large volumes, particularly in Duplin County where large animal farms are prevalent. Mixing in even small volumes of higher productivity waste materials with manure can have large effects; Monte Lamer of Clear Horizons LLC reported that their facility saw a doubling of energy output when they began adding food waste as just 10% of the total volume to a primarily dairy waste digester (Lamer, M., personal communication, July 25, 2014).

Getting the digester to run most efficiently on a given material will require testing and refining as each waste material has a different effect on the chemical environment of the digester. The temperature of the digester and the rate at which new materials are added can be adjusted to stimulate bacterial activity and bring the system into balance. Many large biogas plants, including Novi’s plant in Michigan, have lab testing services in house for testing new waste materials. Smaller plants typically test new waste materials by adding small amounts at a time to their digester and observing the effect, or by maintaining a separate small digester for testing.

*Figure 2. Biogas Production by Waste Type.*
Contracts and Tipping Fees
When securing waste materials to feed into the digester, it is important to identify reliable waste streams, as the digester must be continually fed to remain economically viable. At this stage of the process, it is therefore key to secure long-term, mutually beneficial contracts with waste producers. The experience of many digesters across the country shows, however, that flexibility may still be required as waste sources unexpectedly wane; this may mean at times that a biogas plant accepts materials for free or even at a cost in order to keep the digester running.

In drafting these contracts it is important to spell out who owns the waste at each point in the process, particularly if a tipping fee is not being paid. Additionally, it is important to consider contingency plans and the responsibilities of each party in the event that waste is temporarily unavailable. These kinds of risks can kill an otherwise solid project proposal if parties are not able to agree on how to manage them.

Incorporating tipping fees into the biogas plant business model is key to securing ongoing revenue streams that will keep the plant profitable. Fees will vary depending on the waste source as different waste producers have different ways of dealing with their waste. For industrial producers that are accustomed to paying to dispose of waste in a landfill or in a wastewater treatment plant, tipping fees are fairly simple to negotiate.

For farmers that are accustomed to dealing with waste on their own, a tipping fee may be a barrier to participation. Most digesters that accept livestock waste do so for free, at most requiring that the farmer handle the waste transportation. It is important to note, however, that the farmer does gain value from participation, in the form of odor reduction and improved fertilizer, since the digester effluent has less odor than raw manure and the nutrients it contains are 100% plant-available. Additionally, some costs of maintaining the existing manure management system will be avoided. The plant benefits from this relationship, too, as the participating farms generally store and land apply the digester effluent.

Novi Energy’s Fremont Community Digester is an exception to this trend of digesters accepting manure at no cost. The Fremont Community Digester uses up to 50 different types of waste, according to plant manager Bryan Heiss, including hog waste. Novi charges participating farmers a tipping fee to receive their waste, as well as a fee for land application of the resulting effluent. Transportation and land application is done as a service by Novi with their private fleet of trucks.

Compatible Manure Management Systems
In order to team up with a biogas plant, farms typically need to slightly modify their waste management systems. In Michigan, swine waste is managed using a deep pit system, and the resulting waste stream is more concentrated and higher in solids than with the flushing system typically used on North Carolina hog farms. Excreted swine waste is ~10% solids, and after barn flush it is reduced to ~0.5-2% solids. The percentage of solids required for an anaerobic digester varies with the specific technology, but a free-standing commercial size digester that would be in use as a biogas plant requires 3-10% solids. With swine waste of under 3% solids, a covered lagoon system, more typical of a single-farm installation, is
more appropriate. Thus, in order to benefit from a centralized biogas plant, many NC hog farms would need to modify their current manure management system from barn flushing to scraping in order to maintain the necessary solids content.

In terms of on-farm waste storage, participating farms would need a small storage pit for raw manure and a large lagoon for the effluent (if they were expected to take that material back from the plant). A biogas plant requires the freshest manure possible, and thus a participating farm would likely need storage for just 2-3 days of manure. For the effluent that would be returned to the farm, a larger lagoon would be needed to store the liquid until needed for field application; existing waste treatment lagoons could be transitioned for this purpose.

**Transportation**

Transportation arrangements vary in the case studies used for this report. Logistics and responsible parties vary depending on the waste material itself and the needs of the waste producer. The University of Wisconsin Oshkosh’s community digester provides a good example of the diversity of waste collection arrangements, which include:

- Contracting with a waste hauler
- Farmers using their own equipment to transport to the digester
- City of Oshkosh transporting to the digester
- Collection using the plant’s trucks, particularly when they are low on material

When collecting waste from multiple farms, biosecurity becomes an issue, as disease could potentially be spread from farm to farm. However, none of the case study interviewees experienced this as a barrier. Curt Gooch, an anaerobic digestion and manure management expert at Cornell, said that he would anticipate that biosecurity could be an issue for hog farmers, but that this risk could be managed and that in the end it would not be a barrier to participation (Gooch, C., personal communication, July 23, 2014).

As to the scheduling of trucking activity, Novi’s Fremont digester trucks in waste material 7 days a week and the transportation scheduling largely depends on the waste producer’s needs. It could be expected for the proposed Duplin County facility that trucking would occur 7 days a week as well, in order to keep up with the volume of waste needed to continually feed the digester. Jim Zimmer, site manager for Novi Energy, anticipates that the facility would receive 50 truckloads of waste per day (Zimmer, J., personal communication, August 1, 2014).

As a comparison, the Hometown Bioenergy facility in Minnesota, currently the US’s largest biogas facility with two 1.6 million gallon digester tanks and an electricity generating capacity of eight megawatts, has a truck volume of approximately two trucks per hour. Liquid wastes are brought in 6,000 gallon enclosed tanker trucks which was common across case studies (though truck size varied).

**Onsite Unloading and Storage**

The unloading, storage, and pretreatment of raw waste material is the stage that is most likely to produce odors (Arsova, 2010 & Skott, 2006). Case study plants in proximity to residences and
businesses perform all of these activities indoors so as to minimize odors, whereas those located on farms or in other areas where odors are not a concern typically load and store waste material outdoors, as a cost-reducing measure. These unloading and storage areas are typically maintained under negative air pressure, and air from the facility is filtered through specially designed biofilters before it leaves the facility. It is important to maintain air flow in these enclosed areas, as components of the gasses given off can be harmful to employees who are repeatedly exposed to them in an enclosed area (particularly ammonia and hydrogen sulfide). These gasses can also cause corrosion, so maintaining air flow will help to prolong the life of the facility as well (Clubb, S, personal communication, July 25, 2014).

The Novi plant in Fremont experienced odor complaints in its first few months, several of which were due to the failure to close the doors on the loading dock. This issue was solved by communicating with the truck drivers that the doors must be closed before offloading materials (Ribant, M, personal communication, July 22, 2014). It is not uncommon for plants to experience odor complaints in their first few months of operation; most of the case study interviewees reported that it took a few months to tweak their system and get it running as efficiently and cleanly as intended, whether that was due to problems at the loading site or elsewhere in the system.

The biogas plant will need to be equipped with onsite storage for waste material. The digester runs continuously, and therefore waste materials need to be on-hand at all times to keep the digester productive. Case study digesters typically have space for storage of 2-5 days worth of waste. Depending on the material used and the digester technology, materials may be pre-treated before being loaded into the digester. This could entail mixing wetter waste with dryer waste, grinding up large fibrous materials like crop waste, or pre-heating the materials. These treatments help to regulate the internal consistency of the digester, ensuring complete mixing and more efficient decomposition.

At a site where odor is a major concern, one option for further minimizing odors from loading and storage is to site the loading and preparation area further from the plant and then pipe the prepared materials to the digester. This way the digester may be able to locate close to gas and electric lines, while secluding the receiving area from neighbors.

**The Digester**

Once materials have been received and prepared, they are loaded into a sealed container for decomposition – this is the digester. For a large, centralized facility, this is typically a free standing, above ground tank. There are many different types of digesters, and the technology chosen depends on the volume and consistency of the waste. For centralized processing of swine waste entailing high volumes of a relatively thin waste stream, a complete mix or continuous stirred tank reactor would be in use. This kind of digester is continuously fed with new materials and is equipped with an internal stirring mechanism to regularly agitate the materials and keep the microbial activity high.

The tanks are uniformly heated for maximum efficiency. Heating in the range of 95˚F is ideal for mesophilic bacteria, whereas raising the temperature to 122˚F and above changes the system to thermophilic. The mesophilic process is more common in existing systems, although the thermophilic process is more efficient in that it requires smaller tanks and processes waste faster, and additionally it
achieves more complete pathogen kill (99.9%). The waste heat from the generator itself can be used to provide heat for the digester.

Materials stay in the digester for 15-40 days depending on the exact type of digester and process used. Research shows that a digestion time of 29 days or more maximizes the odor reduction process (Extension, 2012). Some systems include multiple stages of digestion which further reduce odors. Typically, extreme odors from a plant are due to an incomplete digestion process (Iowa DNR, 2004). In Germany, where anaerobic digestion technology is common and well-developed, a three-stage process is used to ensure odor reduction (Bilek, A, personal communication, July 21, 2014).

Generally, however, the digestion process greatly reduces the odor of the waste material. One study demonstrated a 90% reduction when comparing raw manure to the digested effluent (Lorimor, n.d.). A 1998 odor control demonstration project performed by Iowa State University found that “[a]naerobic digesters are very effective at controlling odors, nearly eliminating them from associated manure storage structures” (Burns, 1998). Anecdotally, digester operators on and off farms report that complaints from neighbors about odors – from waste storage and land application – go down drastically following the installation of a digester. With any biogas plant there will be instances of odors in the event of a problem in the system, and, in general, the amount of odor depends heavily on how well managed the system is. According to one expert, 3 to 4 days per year of odor is to be expected with a well-run plant (Bilek, A., Personal Communication, July 21, 2014).

**Effluent**

Once the waste is processed through the digester, the volume of the material is not significantly reduced. Thus, the resulting volume of effluent is comparable to the volume of waste, however, it has much less odor, has fewer pathogens, and is higher in plant-available nutrients than the raw waste.

How this effluent is processed depends largely on the consistency of the waste materials used. For materials higher in solids, those solids can be separated out and processed, usually by heating to kill remaining pathogens and completely dry the material, for use as a soil amendment marketed to home gardeners or as livestock bedding. The liquid effluent is then used as a liquid fertilizer and is land applied. These products become additional revenue streams for the plant.

Swine waste – in contrast to dairy waste or food waste – is a fairly dilute waste stream. Solid separation may not be economically feasible given the small amount of product that would result. As yet, the existing systems that process swine waste do not include solid separation components. With this waste material, all of the effluent is instead treated as liquid effluent for land application as fertilizer.

In the case study examples, centralized plants typically have a tank that holds a few days of effluent, but then the liquid is transferred to participating farms for further storage and land application. Trucks that were sent out to receive raw manure would take a load of effluent for drop-off at the farm prior to filling up. Thus, in the examples studied, participating farms still had to maintain a lagoon to hold this effluent. Novi’s Fremont Community Digester, however, operates slightly differently; Novi takes responsibility for the land application, charging a fee for the service.
Fertilizing with digestate, liquid or solid, has benefits over land application of raw manures. Case study interviewees reported that participating farmers are able to land apply with a more flexible schedule due to the low odor of the digestate and that they see increased crop productivity as compared to using raw manure. Where solid digestate is used, farmers were able to transition to no-till practices, since the odor of the solid digestate does not necessitate that it be tilled into the soil (McEliece, A, personal communication, July 29, 2014).

Additional treatment systems can be added to the digester to further upgrade the liquid effluent. In this way, the anaerobic digester could be seen as just one component situated in the middle of a system designed to improve water quality. In Dane County, Wisconsin, digesters include equipment to remove phosphorous. Loyd Ray Farms’s system, an on-farm digester in Yadkin County North Carolina, features an aeration basin which removes pathogens, heavy metals, and nutrients. The wastewater can then be recycled back to the barns for flushing or used as irrigation-quality water. The feasibility of adding these features depends on the balance between capital cost and the need for the resulting product in the local area, however, the centralization of waste for a digester presents a real opportunity to further clean up the waste stream, similar to the way Dane County and Loyd Ray have done.

**Spill Management**

One of the concerns raised in Duplin County and other communities about biogas plants is the potential for spills. Of the fifteen plants studied, one has had a major spill event. The Dane County Digester in Wisconsin experienced two spills in the winter of 2013. Monte Lamer of Clear Horizons LLC, the plant operator, explained that these spills were due to an exceptionally cold winter, as fittings on the pipes that transport the raw manure broke when the ground shifted and froze. The leaks started on a Sunday evening when there were no staff at the plant, and by the time is was discovered early the next morning, 380,000 gallons of raw manure had spilled. The plant, with the assistance of its three farm partners, immediately began working to stop the flow and cleanup the manure. Ditches from the facility were dammed to prevent the material from entering waterways. It took seven days of pumping to remove all of the spilled material and the participating farms pitched in to help.

Following the incident, pipe fittings were replaced with a flexible fitting which could withstand shifting and freezing. Valves were installed on the digester tanks to prevent the tanks from back-flowing in the event that the input or output pipes failed. While community members were upset about the spill, many recognized that prior to the existence of the digester this material would have eventually ended up in the waterways anyway and that the digester still had a positive impact overall. Now that the digester was in place, it diverted and processed the raw manure, and additional technology was used to remove phosphorous from the effluent, thus improving the quality of local waterways.

Designing plants with containment areas around the tanks is also common. Developers of the Hometown BioEnergy plant in Minnesota said that regulators applied the same requirements to their plant effluent as they do to oil and other hazardous materials. The plant was designed with containment areas around all of the digester tanks, and the effluent lagoon had to meet strict seepage requirements. While protecting against spills is important, these requirements may go a bit too far and...
Pose undue costs, as the properties of the digester effluent make it a less environmentally harmful material than the raw waste.

Maintenance
Digester maintenance is an important consideration, particularly in areas where these technologies are fairly new. In the case of a privately owned, centralized facility, the maintenance will likely be taken care of in-house. For smaller facilities, it is important to consider maintenance contracts with the system designer.

New facilities also offer an opportunity to work with local community colleges to train biogas technicians, thus bringing down costs for the industry through local expertise while also providing new career possibilities for residents. There are several examples across the country of colleges and universities that partner with private digesters or run their own as part of an integrated curriculum. Core skills in biology and electrical engineering are a component of these programs and are widely applicable. Examples include Vermont Tech in Randolph, Vermont, University of Wisconsin Oshkosh, and Bellingham Technical College in Bellingham, Washington.

Ownership
Private ownership of a centralized biogas plant is rare among the existing plants in the US. Currently, about 10% of digesters are privately owned, according to AgSTAR (Costa, A, personal communication, July 31, 2014). The case studies in this report show a wide range of players involved in the ownership and operation of these facilities. The county government in Dane County Wisconsin is particularly involved in getting digesters installed and has funds set aside for the purchase of capital equipment. They maintain ownership of this equipment and then lease it to a renewable energy consultant who runs the plant. Dane County has participated in the construction of three digesters thus far and has plans for at least two more. Other entities involved in ownership and operations include:

- Educational institutions
- Public and private utilities
- Landfills
- Wastewater treatment plants
- Corporations with sustainability goals
- Waste producers – industrial and food waste
- Waste recycling/hauling companies
- Industrial composting companies
- Farm associations

Experts in the field indicate, however, that there is an increasing trend toward private ownership and that this has many benefits for farmers and the industry as a whole (Costa, A, personal communication, July 31, 2014). Renewable energy consultants who have long been involved in the design and installation of these systems are well equipped to address the many complexities involved in financing, designing, and operating plants for maximum efficiency.
Partnerships between third-party energy consultants and some of the other entities mentioned bring together the best of both worlds and can be very beneficial in siting a project. Through partnerships, a centralized digester could be sited at an existing waste management facility, on a large farm, or on college or university property. Such locations may allow tax benefits for a facility or simply give the plant access to an onsite waste source while still integrating waste from other sources.

Community college and university partnerships offer the opportunity for both research on improving biogas productivity as well as workforce development for the biogas industry, as discussed in the maintenance section above. Additionally, campuses provide a waste source from dining halls and other institutional wastes.

**Energy Products**

**Electricity**

Biogas produced via anaerobic digestion can be transformed into several different valuable energy products. In North Carolina, the first, and most common, is electricity. Like many states, North Carolina has a renewable energy portfolio standard (REPS) which mandates that utilities supply 12.5% of their electricity sales from renewable sources by 2021. North Carolina is unique in that it is the only state where swine waste is included in the REPS. This, and the associated tradable renewable energy credits (RECs), is the most significant policy driver in the state for installation of biogas systems, incentivizing electricity production over other forms of biogas upgrading. Biogas systems are also eligible for carbon credits, no matter what form the energy production takes, which brings in another source of revenue.

To generate electricity, the biogas – which is 50-60% methane – is used as fuel for a generator to produce electricity for use onsite and for sale back to the grid. In terms of community impacts, this is the noisiest part of the process. However, as one interviewee pointed out, the plant operators have to listen to the noise of the generator, too, so mufflers are generally part of the design. The generators are usually indoors as well, further reducing the noise radius. None of the case studies reported noise complaints from neighbors.

The cost of connecting into the electrical grid is highly variable by site and can add considerably to capital costs. Selling the electricity to a utility also requires a power purchase agreement (PPA) which sets the rate per kilowatt hour for the term of the contract, typically 20 years. This contract also lays out the ownership of the RECs and carbon credits between the utility and the biogas plant owner. The rates set in the PPA, and the ownership structure of the RECs, are a key determinant of the project economics. Prices for the RECs themselves are highly variable, depending on the volume of power generated, and are generally not made public.

**Natural Gas**

A second option for energy production from biogas is to upgrade the gas and inject it into the natural gas pipeline. This entails additional equipment to purify and condense the gas to pipeline standards. Depending on the price of natural gas, this can be a more profitable option than electricity. This option requires connection to existing natural gas lines, which puts a constraint on the facility location.
Production of natural gas would be eligible for carbon credits, but not necessarily for North Carolina’s renewable energy credits. Only if the natural gas generated from the swine waste facility were sent to a natural gas power plant would the system be eligible for RECs in North Carolina.

**Compressed Natural Gas (CNG)**

A final option is to treat the biogas to produce compressed natural gas (CNG). CNG is a vehicle fuel which can be used on its own or in combination with diesel fuel, depending on the engine. There are a handful of examples across the country of large farms that have transitioned their tractors and farm vehicles to CNG and opened filling stations available to the public. Production of CNG does not qualify for state RECs but does qualify for compliance certificates under the federal renewable fuel standards, as well as carbon credits. Vehicle fuel tends to command a higher price than electricity, so producing CNG instead of electricity can boost project revenues significantly. However, as North Carolina’s current renewable energy policy places an emphasis on electricity production, the infrastructure and policy drivers around CNG production are lacking.

**Heat**

Production of biogas also produces waste heat which can be captured and used onsite. Some of this heat is generally used to run the digester itself, reducing plant energy costs and improving system efficiency. The heat can also be piped to provide heat for buildings onsite or other onsite industrial processes.

**Alternative Configurations**

With each of these different options for energy production, there are different configurations that could be alternatives to the centralized digester model. In 2013, Duke’s Nicholas School for the Environment undertook a study which sought to determine the least cost option for production of electricity from swine waste. Two configurations emerged as the leading designs and offer alternatives to a strictly centralized system with waste trucking. These configurations are: distributed electricity generation and centralized directed biogas (Prasodjo, 2013). A third alternative, referred to here as the community digester model, is also discussed. While it was not included in the Duke study, it is a model that has been successfully employed in a few different states.

**Distributed Electricity Generation**

The distributed electricity generation model is the model currently employed in Duplin County and North Carolina generally. Anaerobic digester systems are installed on individual farms and produce electricity for that specific facility or to be sold to the grid. Under this scenario, the majority of the wastes come from onsite and the effluent is also dealt with on site. The drawback of the distributed model is the high cost of installing capital equipment at each individual site, however, it lowers the risks associated with waste transportation and effluent management. This was one of the configurations identified by the Duke study as a least-cost configuration for the production of electricity from swine waste.
Centralized Directed Biogas
A second option is to connect these on-farm digesters by pipeline to move the biogas. Biogas would be produced in anaerobic digesters on individual farms and then piped via PVC pipe to a central facility where it would be purified and compressed for injection into the natural gas pipeline. The primary advantage of this configuration is that it reduces the overall capital costs, since gas purifying equipment only needs to be purchased for one site. Installing pipeline poses right-of-way concerns, so this system may be best employed on adjacent farms. This was the second configuration identified by the Duke study as a least-cost configuration for the production of electricity from swine waste.

Community Digester
A final option is to pipe the manure itself to a digester located on a central farm. This would again be most feasible with a handful of adjacent farms. Under this configuration, the raw manure would be pumped regularly out of the hog barns and piped through PVC pipe to a large digester located on one of the participating farms. There the biogas could be processed into electricity or natural gas. This configuration brings down capital costs and still benefits from on-farm siting, which brings down tax and permitting costs and generally avoids community concerns that are common for centralized digesters. This system is currently in use in Dane County Wisconsin, where they use 8-inch PVC piping to connect from dairy barns to a digester; these pipes transport 90,000 to 100,000 gallons of manure a day, and the longest pipe is a half-mile long.

Conclusion
Biogas production is not just about renewable energy generation, it is also about improved waste management. The ability to extract value from a waste stream through energy production provides the incentive for further cleaning and upgrading of that waste stream. Thus, biogas production results not just in renewable energy, but also in improved air and water quality, reduced greenhouse gas emissions, and higher quality fertilizer. From the community’s perspective, these facilities can be expected to reduce odors from participating farms, since raw manure storage and application will be reduced. However, the farms may need to maintain their existing waste lagoons to store the plant effluent.

There are many successful models across the country of centralized digesters that are integrated into their host community. However, each digester facility is unique and must be designed to respond to the waste management needs of the local area. Successful facilities were found to be those that can efficiently match the available waste sources to their digester technology, and further match the digester effluent to local soil additive needs.

Some of these plants are hosted by communities that chose to proactively support the development of biogas systems. The drivers behind these efforts varied and included addressing nutrient imbalances in local lakes, diverting waste from landfills and wastewater treatment plants, improving quality of life surrounding large animal feeding operations and increasing renewable energy resources. Communities that successfully encouraged biogas development convened stakeholders and regulators ahead of time to ease the pre-development process and address regulatory problems before they manifested. They raised community awareness, building support for biogas production and smoothing the way for when a
viable proposal came in. Finally, they formed creative partnerships of public and private actors to address financing, facility siting and other barriers to implementation, ultimately giving way to projects that benefited all parties.
**Interviewees**

Amanda Bilek, Government Affairs Manager, Great Plains Institute

Scott Clubb, Digester Manager, Amana Farms

Alison Costa, Program Manager, AgSTAR US EPA

Kelsey Dillon, Vice President, Avant Energy

Curt Gooch, Dairy Environmental Systems and Sustainability Engineer, Cornell University

Bryan Heiss, Plant Manager, Fremont Community Digester

Brian Langolf, Plant Manager, University of Wisconsin-Oshkosh Biogas Systems

Monte Lamer, Plant Operations Manager, Clear Horizons LLC

Kate Shepherd Lebrato, Marketing and Communications Manager, NC Green Power

Angie McEliece, Environmental Consultant, RCM International

Michele Ribant, Director of Neighborhood and Economic Development, City of Fremont Michigan

Gus Simmons, Director of Bioenergy, Cavannaugh and Associates

Tanja Vujic, J.D., Energy Consultant

James Wolfe, Economic Development Director, Duplin County

Jim Zimmer, Site Manager, Novi Energy
References


Appendix: Case Studies

Case studies for this report were selected with a preference for facilities which: 1) use of manure as a waste material, 2) display some degree of centralization, and 3) have electrical capacity above 1MW. A total of fifteen cases across the country were identified through news articles and online research. Where possible phone interviews were conducted by the author; the seven profiles presented here are the case studies where the most detail was available through interviews, news articles, and web resources.

Amana Farms Digester
West Amana, IA

Established: 2009

Owner: Amana Farms

Operator: Amana Farms

Cost: $4.9 million

Partners: Iowa State University (waste material research), The Amana Society (financing), Iowa Office of Energy Independence Power Fund Board (financing), USDA (financing)

Electricity Generation Capacity: 2.6MW

Waste Materials: Dairy waste, food processing waste, feed waste, biodiesel plant waste

More Info: The Amana Farms digester runs off of dairy waste from onsite and other materials brought in for a tipping fee. The digester has a partnership with Iowa State University to research new waste materials and is always seeking new inputs.


Dane County Community Digesters
Multiple sites in Dane County, WI

Established: 2013

Owner: Ownership varies by facility and includes Gunderson Health Systems and Dane County in partnership with Clear Horizons, LLC

Operator: Clear Horizons, LLC

Cost: Unknown
**Partners:** Dane County (financing), Purple Cow Organics, Madison Gas and Electric, US Biogas, C.G. Schmidt

**Electricity Generation Capacity:** 2MW

**Waste Materials:** Dairy waste, food processing waste

**More Info:** The establishment of digesters in Dane County, Wisconsin was driven by phosphorous pollution in local lakes. The Dane County government has been involved in the construction of three out of five of the digesters that are currently in the county and has two more planned. Each of the county’s digesters includes additional technologies to remove phosphorous from the effluent, with the goal of removing 60% of the phosphorous from the waste stream. One of the county’s facilities in Waunakee has experienced four incidents in the past year including manure spills and a fire. At the time of this writing local officials are seeking new management but remain committed to the digester as a critical piece of infrastructure in improving environmental quality.

**Fremont Community Digester**
Fremont, MI

**Established:** 2012

**Owner:** Novi Energy

**Operator:** Novi Energy

**Cost:** $22 million

**Partners:** Gerber, Michigan Public Service Commission

**Electricity Generation Capacity:** 3MW

**Waste Materials:** Food waste, agricultural waste including swine manure. No more than 15% of waste materials from any one source.

**More Info:** This is Novi’s first biogas plant and it stands out from the other case study examples as a wholly privately owned and operated site. It is also unusual in that it charges a tipping fee both for receiving manure and for field applying the digester effluent – both of which is done in house by Novi’s fleet of trucks. The plant receives hog waste from four to five farms, vacuuming the waste out of deep pit storage systems. Its digester is maintained at high heat, improving the efficiency of digestion and boosting pathogen kill. The plant, like many of the case studies, experienced odor complaints in their first few months of operation which were solved through further adjustments to the system.

www.fcdbiogas.com
**Hometown BioEnergy**
Le Sueur County, MN

**Established:** 2013

**Owner:** Minnesota Municipal Power Agency

**Operator:** Avant Energy

**Cost:** $45 million

**Partners:** Xergi A/S

**Electricity Generation Capacity:** 8MW

**Waste Materials:** Dairy waste, corn silage, food processing waste

**More info:** This facility is the largest biogas plant to date in the US with a capacity of eight megawatts. The facility brings in waste from a 60 mile radius in 6,000 gallon enclosed tanker trucks and has a truck volume of 2 trucks per hour. Community acceptance was an issue for this facility and Avant Energy met with community members repeatedly during the multi-year predevelopment phase to address concerns. To address odor concerns they constructed a fully enclosed receiving hall with negative air pressure and air filtration and developed a comprehensive odor management plan. Due to the volume of waste processed at the facility an Environmental Assessment Worksheet (EAW) was required by the Minnesota Pollution Control Agency; it was determined that the facility would not have significant environmental impacts and an Environmental Impact Statement was not required. The EAW process alone took 9 months. The facility is sited on a former gravel pit site in an industrial park.


**Hooley Community Digester**
Port of Tillamook Bay, OR

**Established:** 2003

**Owner:** Port of Tillamook Bay

**Operator:** Port of Tillamook Bay

**Cost:** Unknown

**Partners:** RCM International, Tillamook Public Utility, District and Tillamook County Creamery Association

**Electricity Generation Capacity:** 1MW
**Waste Materials:** Dairy waste from 7,000 cows on 7-11 farms, other organic wastes

**More Info:** Manure is trucked to the facility in 5,000 gallon tanker trucks, the facility receives 60,000 gallons of waste per day. The facility is located in the Port of Tillamook Bay’s 1,600 acre industrial park. Project financing included a $1.5 million congressional appropriation for a feasibility study and a Department of Energy grant in an unknown amount.


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**Napoleon Biogas**
Harrison Township, OH

**Established:** 2013

**Owner:** CH4 Biogas

**Operator:** CH4 Biogas

**Cost:** Unknown

**Partners:** Campbell’s Soup (purchases 100% of power generated), BNB Napoleon Biogas (investor), Eksport Kredit Fonden (financing)

**Electricity Generation Capacity:** 2.8MW

**Waste Materials:** Dairy waste, food processing waste

**More Info:** Napoleon biogas is one of several biogas plants connected to a Campbell’s Soup facility and serves as an example of a successful partnership between an industrial waste producer and a renewable energy firm. In addition to waste from Campbell’s production process it accepts waste from dairy farms.

www.ch4biogas.com/projects/napoleon-biogas/

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**UW Oshkosh Biodigester 1**
Oshkosh, WI

**Established:** 2011

**Owner:** UW Oshkosh Foundation, Inc.

**Operator:** University of Wisconsin-Oshkosh

**Cost:** $5 million

Electricity Generation Capacity: 370kW

Waste Materials: Food waste, yard waste, animal bedding waste and curbside organics. Occasionally additional biogas is received from Oshkosh City's waste-water treatment plant.

More Info: This facility is located on the University of Wisconsin-Oshkosh campus and is one of three biogas projects that the University has established. This digester uses a dry fermentation process which requires waste materials with at least 25% solids. The facility fills 8% of the University's electricity need and provides research and educational opportunities for students.

www.uwosh.edu/biodigester/About/uw-oshkosh-biodigester