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# Introduction

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Many livestock facilities in the United States handle manure as liquids and slurries. Stored manure liquids and slurries decompose anaerobically (i.e., in the absence of oxygen) producing large volumes of gas. This gas is often referred to as biogas. Biogas contains between 60 and 80 percent methane (about 600-800 BTU/ft<sup>3</sup>) and is considered a renewable energy resource.

Substantial opportunities exist across the country to recover and use biogas energy by adapting manure management practices to include biogas generation and collection. This handbook focuses on identifying and evaluating opportunities for recovering and utilizing this energy through the implementation of biogas technology.

This handbook is for livestock producers, developers, investors, and others in the agricultural and energy industry that may consider biogas technology as a livestock manure management option. The handbook provides a step-by-step method to determine whether a particular biogas recovery system is appropriate for a livestock facility. This handbook complements the guidance and other materials provided by the AgSTAR program to the development of biogas technologies at commercial farms in the United States.

## The AgSTAR Program

The AgSTAR Program is a voluntary effort jointly sponsored by the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and the U.S. Department of Energy. The program encourages the use of biogas capture and utilization at animal feeding operations that manage manures as liquids and slurries. A biogas system reduces emissions of methane, a greenhouse gas, while achieving other environmental benefits.

In addition, converting livestock wastes into an energy source may increase net farm income.

AgSTAR currently provides the following reports and tools to assist livestock producers and other interested parties in making informed business decisions about the financial and environmental performance of these technologies:

### General Information

*The AgSTAR Program - Managing Manure with Biogas Recovery Systems*

*AgSTAR Digest*: an annual newsletter

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## Project Development Tools

*AgSTAR Handbook: A Manual for Developing Biogas Systems at Commercial Farms in the United States*

*FarmWare: A pre-feasibility software package that accompanies the AgSTAR Handbook*

*Industry Directory for On-farm Biogas Recovery Systems: a listing of digester designers and equipment suppliers*

*Funding On-farm Biogas Recovery Systems: A Guide to National and State Funding Resources*

*Market Opportunities for Biogas Recovery Systems: A Guide to Identifying Candidates for On-farm and Centralized Systems*

## Environmental Performance

*Dairy Cattle Manure Management: A Case Study of a Plug Flow Anaerobic Digestion System*

*Swine Manure Management: A Case Study of a Covered Lagoon Anaerobic Digestion System (under development)*

*Swine Manure: A Case Study of a Complete Mix Digester System (under development)*

All these products are free of charge and can be downloaded at [www.epa.gov/agstar](http://www.epa.gov/agstar) or ordered through the AgSTAR Hotline 1-800-95AgSTAR (1-800-952-4782).

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## Organization of this Handbook

This handbook is organized into chapters according to the process of biogas project development as presented in Exhibit 1. Chapter 1 provides an overview of the technology. The subsequent chapters lead you through two stages of project development. Supporting information is included in the appendices. The two stages of project development are:

**I. Project Feasibility Assessment.** Chapters 2, 3, and 4 provide guidance on screening for project opportunities, selecting a gas use option and conducting site-assessments to identify technically appropriate and cost-effective biogas recovery option(s). Chapter 9 examines the feasibility of centralized digester projects.

**II. Project Implementation.** Chapters 5 through 8 discuss the steps to develop a biogas project. The steps include: securing an energy contract; selecting a developer; obtaining project financing; and complying with permitting requirements.

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**Exhibit 1** Project Development Process

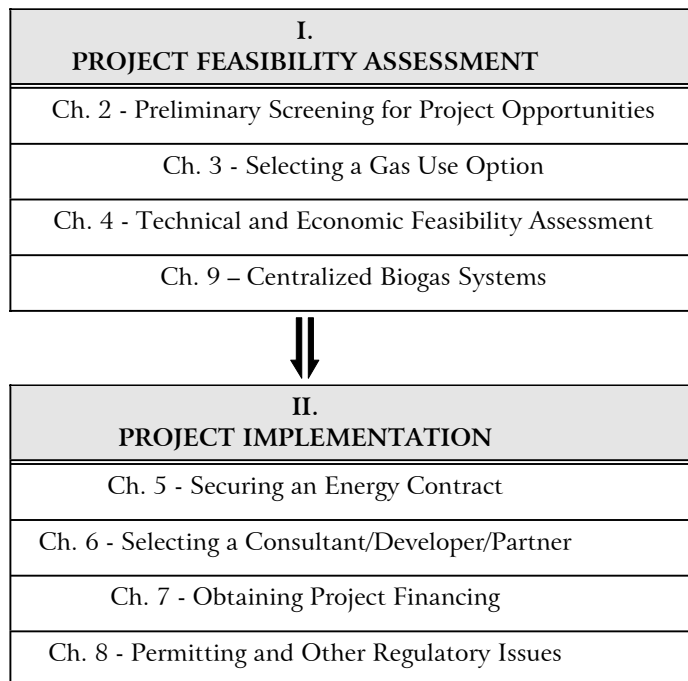


Exhibit 2 summarizes how this handbook can be used to meet various objectives. The first column lists several common objectives and the second column lists the chapter to consult and key elements of that chapter.

# Introduction

## Exhibit 2 How to use this Handbook - Quick Reference

OBJECTIVE	CHAPTER TO CONSULT
<b>I WANT AN OVERVIEW OF BIOGAS TECHNOLOGY?</b> <ul style="list-style-type: none"> <li>What is biogas technology?</li> <li>Why would I use biogas technology?</li> <li>How successful has biogas technology been?</li> </ul>	<b>1. Overview of Biogas Technology</b> <ol style="list-style-type: none"> <li>1.1 What is Biogas Technology?</li> <li>1.2 Benefits of Biogas Technology</li> <li>1.3 The U.S. Biogas Experience</li> </ol>
<i>Part I. Project Feasibility Assessment</i>	
<b>SHOULD I CONSIDER BIOGAS RECOVERY AS AN OPTION FOR MY LIVESTOCK FACILITY?</b> <ul style="list-style-type: none"> <li>How do I know if my facility is ready to operate a biogas system?</li> <li>What information do I need to identify promising opportunities for a biogas system?</li> <li>How do I know if I have the skills and support to operate a biogas system?</li> </ul>	<b>2. Preliminary Screening for Project Opportunities</b> <ol style="list-style-type: none"> <li>2.1 Is Your Facility “Large”, with Animals in Confinement?</li> <li>2.2 Is Your Manure Management Compatible with Biogas Technology?</li> <li>2.3 Is there a Use for Energy?</li> <li>2.4 Can You Manage the Farm Effectively?</li> <li>2.5 Initial Appraisal Results</li> </ol>
<b>CAN I USE BIOGAS AT MY FACILITY ?</b> <ul style="list-style-type: none"> <li>What are the main uses of biogas?</li> <li>How do I determine which biogas utilization option will maximize economic return?</li> <li>What are the electricity generation options? How do I determine which option is suitable for my facility?</li> </ul>	<b>3. Selecting a Gas Use Option</b> <ol style="list-style-type: none"> <li>3.1 Electricity Generation</li> <li>3.2 Direct Combustion</li> <li>3.3 Other Options</li> </ol>
<b>IS A BIOGAS SYSTEM TECHNICALLY AND FINANCIALLY FEASIBLE FOR MY FACILITY ?</b> <ul style="list-style-type: none"> <li>How do I decide which biogas technology is appropriate for my livestock facility?</li> <li>What information do I need to evaluate the technical and economic feasibility of a biogas project?</li> <li>How do I compare the costs and revenues from a biogas project?</li> </ul>	<b>4. Technical and Economic Feasibility Assessment</b> <ol style="list-style-type: none"> <li>4.1 Match a Digester to Your Facility’s Waste Management Practices</li> <li>4.2 Complete Evaluation Sheets</li> <li>4.3 Enter Information into FarmWare</li> <li>4.4 Evaluate Results</li> </ol>
<i>Part II. Project Implementation</i>	
<b>HOW DO I CLOSE THE UTILITY DEAL?</b> <ul style="list-style-type: none"> <li>Do I need a utility deal?</li> <li>How do I know if I’m getting the best possible deal?</li> <li>How do I negotiate a “win/win” deal?</li> <li>Where do I get help?</li> </ul>	<b>5. Securing an Energy Contract</b> <ol style="list-style-type: none"> <li>5.1 Operation Modes</li> <li>5.2 Interconnection Requirements</li> <li>5.3 Who to Contact</li> <li>5.4 What to Ask for</li> <li>5.5 Elements of and Agreement</li> <li>5.6 Why Negotiate and What to Watch Out For</li> <li>5.7 Future Possibilities for Selling Electricity</li> </ol>

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OBJECTIVE	CHAPTER TO CONSULT
<b>HOW DO I SELECT A CONSULTANT/DEVELOPER/PARTNER?</b> <ul style="list-style-type: none"> <li>• How do I know whether I need a consultant/developer/partner?</li> <li>• What should I look for in a consultant/developer/partner?</li> <li>• What should I include in a contract?</li> </ul>	<b>6. Selecting a Consultant/Developer/Partner</b> <ul style="list-style-type: none"> <li>6.1 The Do-it-Yourself/Turnkey Decision</li> <li>6.2 Selecting a Consultant/Consulting Firm</li> <li>6.3 Selecting a Turn-Key Developer</li> <li>6.4 Selecting a Partner</li> <li>6.5 Preparing a Contract</li> </ul>
<b>HOW DO I GET FINANCING FOR THE PROJECT?</b> <ul style="list-style-type: none"> <li>• What are the sources of funding for biogas projects?</li> <li>• What do lenders/investors look for?</li> <li>• How do I evaluate different financing options?</li> </ul>	<b>7. Obtaining Project Financing</b> <ul style="list-style-type: none"> <li>7.1 Financing: What Lenders/Investors Look For</li> <li>7.2 Financing Approaches</li> <li>7.3 Capital Cost of Different Financing Alternatives</li> </ul>
<b>WHAT DO I NEED TO KNOW ABOUT THE PERMITTING PROCESS?</b> <ul style="list-style-type: none"> <li>• What permits do I need?</li> <li>• How do I get these permits?</li> <li>• Do I need to worry about meeting air quality emission standards from IC engines?</li> </ul>	<b>8. Permitting and Other Regulatory Issues</b> <ul style="list-style-type: none"> <li>8.1 The Permitting Process</li> <li>8.2 Zoning and Permitting</li> <li>8.3 Community Acceptance</li> <li>8.4 Regulations Governing Air Emissions from Energy Recovery Systems</li> </ul>
<b>IS A CENTRALIZED BIOGAS SYSTEM FEASIBLE?</b> <ul style="list-style-type: none"> <li>• How do I perform a preliminary feasibility evaluation?</li> <li>• Should we establish a formal legal entity?</li> <li>• How do I select a consultant?</li> <li>• What are the elements of a feasibility study?</li> <li>• What are the next steps if I want to proceed?</li> </ul>	<b>9. Centralized Biogas Systems</b> <ul style="list-style-type: none"> <li>9.1 Preliminary Evaluation</li> <li>9.2 Organization</li> <li>9.3 Selecting a Consultant</li> <li>9.4 The Feasibility Study</li> <li>9.5 Next Steps</li> </ul>
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<b>WHERE CAN I GET A LIST OF NRCS AND OTHER KEY CONTACTS?</b>	<b>Appendix B:</b> List of NRCS and U.S. Department of Energy Regional Contacts.
<b>WHERE CAN I GET HELP ON USING FARMWARE?</b>	<b>Appendix C:</b> FarmWare User's Manual - Version 3.0
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<b>WHERE CAN I GET THE NRCS PRACTICE STANDARDS?</b>	<b>Appendix F:</b> NRCS Practice Standards
<b>WHAT INFORMATION IS NEEDED FROM THE UTILITY FOR A PRELIMINARY FEASIBILITY ASSESSMENT?</b>	<b>Appendix G:</b> Utility Letter of Request (Sample)
<b>WHERE CAN I SEE WHAT TYPICAL UTILITY RATE SCHEDULES LOOK LIKE?</b>	<b>Appendix H:</b> Utility Rate Schedules, Riders, and Interconnection Requirements (Samples)
<b>WHERE CAN I GET A LIST OF DEVELOPERS AND EQUIPMENT SUPPLIERS?</b>	<b>Appendix I:</b> List of Designers, Equipment Suppliers, and Vendors
<b>WHERE CAN I GET DEFINITIONS OF TECHNICAL TERMS MENTIONED IN THIS HANDBOOK?</b>	<b>Glossary</b>

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The U.S. biogas experience in the 1970s and 1980s has demonstrated that biogas technology is not applicable for all farms. In many situations however, it can be a cost-effective and environmentally friendly method for treating manure and liquid waste. Biogas production is best suited for farms that handle large amounts of manure as a liquid, slurry, or semi-solid with little or no bedding added. Biogas systems require a financial investment and a management responsibility. The system must be designed by an experienced animal waste digester designer, who is well versed with the common problems associated with these types of systems. Additionally, the farm owner or operator must be committed to the digester's success.

This chapter provides an overview of biogas technology and opportunities to use this technology in livestock facilities across the United States. First, a brief description of biogas technology is provided. Then the benefits of biogas technology are discussed. Finally, the experience and status of biogas technology development in the United States are described.

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## 1-1. What are the Components of a Biogas System?

Biogas technology is a manure management tool that promotes the recovery and use of biogas as energy by adapting manure management practices to collect biogas. The biogas can be used as a fuel source to generate electricity for on-farm use or for sale to the electrical grid, or for heating or cooling needs. The biologically stabilized byproducts of anaerobic digestion can be used in a number of ways, depending on local needs and resources. Successful byproduct applications include use as a crop fertilizer, bedding, and as aquaculture supplements.

A typical biogas system consists of the following components:

- ◆ Manure collection
- ◆ Anaerobic digester
- ◆ Effluent storage
- ◆ Gas handling
- ◆ Gas use.

Each of these components is discussed briefly.

### 1-1.1 Manure Collection

Livestock facilities use manure management systems to collect and store manure because of sanitary, environmental, and farm operational considerations. Manure is collected and stored as either liquids, slurries, semi-solids, or solids.

- ◆ **Raw Manure.** Manure is excreted with a solids content of 8 to 25 percent, depending upon animal type. It can be diluted by various process waters or thickened by air drying or by adding bedding materials.
- ◆ **Liquid Manure.** Manure handled as a liquid has been diluted to a solids content of less than 5 percent. This manure is typically “flushed” from where it is excreted, using fresh or recycled water. The manure and flush water can be pumped to treatment and storage tanks, ponds, lagoons, or other suitable structures before land application. Liquid manure systems may be adapted for biogas production and energy recovery in “warm” climates. In colder climates, biogas recovery can be used, but is usually limited to gas flaring for odor control.
- ◆ **Slurry Manure.** Manure handled as a slurry has been diluted to a solids content of about 5 to 10 percent. Slurry manure is usually collected by a mechanical “scraper” system. This manure can be pumped, and is often treated or stored in tanks, ponds, or lagoons prior to land application. Some amount of water is generally mixed

with the manure to create a slurry. For example, spilled drinking water mixes with pig manure to create a slurry. Manure managed in this manner may be used for biogas recovery and energy production, depending on climate and dilution factors.

- ◆ **Semi-Solid Manure.** Manure handled as a semi-solid has a solids content of 10 to 20 percent. This manure is typically scraped. Water is not added to the manure, and the manure is typically stored until it is spread on local fields. Fresh scraped manure (less than one week old) can be used for biogas and energy production in all climates, because it can be heated to promote bacterial growth.
- ◆ **Solid Manure.** Manure with a solids content of greater than 20 percent is handled as a solid by a scoop loader. Aged solid manure or manure that is left “unmanaged” (i.e., is left in the pasture where it is deposited by the animals) or allowed to dry is not suitable for biogas recovery.

### 1-1.2 Digester Types

The digester is the component of the manure management system that optimizes naturally occurring anaerobic bacteria to decompose and treat the manure while producing biogas. Digesters are covered with an air-tight impermeable cover to trap the biogas for on-farm energy use. The choice of which digester to use is driven by the existing (or planned) manure handling system at the facility. The digester must be designed to operate as part of the facility's operations. One of three basic options will generally be suitable for most conditions. Appendix F contains several NRCS Conservation Practice Standards for digesters. Exhibit 1-1 summarizes the main characteristics of these digester technologies:

- ◆ **Covered Lagoon Digester.** Covered lagoons are used to treat and produce biogas from liquid manure with less than 3 percent solids. Generally, large lagoon volumes are required, preferably with depths greater than 12 feet. The typical volume of the required lagoon can be roughly estimated by multiplying the daily manure flush volume by 40 to 60 days. Covered

**Exhibit 1-1** Summary Characteristics of Digester Technologies

Characteristics	Covered Lagoon	Complete Mix Digester	Plug Flow Digester	Fixed Film
<b>Digestion Vessel</b>	Deep Lagoon	Round/Square In/Above-Ground Tank	Rectangular In-Ground Tank	Above Ground Tank
<b>Level of Technology</b>	Low	Medium	Low	Medium
<b>Supplemental Heat</b>	No	Yes	Yes	No
<b>Total Solids</b>	0.5 - 3%	3 - 10%	11 - 13%	3%
<b>Solids Characteristics</b>	Fine	Coarse	Coarse	Very Fine
<b>HRT* (days)</b>	40 - 60	15+	15+	2-3
<b>Farm Type</b>	Dairy, Hog	Dairy, Hog	Dairy Only	Dairy, Hog
<b>Optimum Location</b>	Temperate and Warm Climates	All Climates	All Climates	Temperate and Warm

\* Hydraulic Retention Time (HRT) is the average number of days a volume of manure remains in the digester.

lagoons for energy recovery are compatible with flush manure systems in warm climates. Covered lagoons may be used in cold climates for seasonal biogas recovery and odor control (gas flaring). There are two types of covers, bank-to-bank and modular. A bank-to-bank cover is used in moderate to heavy rainfall regions. A modular cover is used for arid regions. Exhibit 1-2 illustrates a modular floating cover for lagoon applications. Typically, multiple modules cover the lagoon surface and can be fabricated from various materials.

◆ **Complete Mix Digester.** Complete mix digesters are engineered tanks, above or below ground, that treat slurry manure with a solids concentration in the range of 3 to 10 percent. These structures require less land than lagoons and are heated. Complete mix digesters are compatible with combinations of scraped and flushed manure.

◆ **Plug Flow Digester:** Plug flow digesters are engineered, heated, rectangular tanks that treat scraped *dairy* manure with a range of 11 to

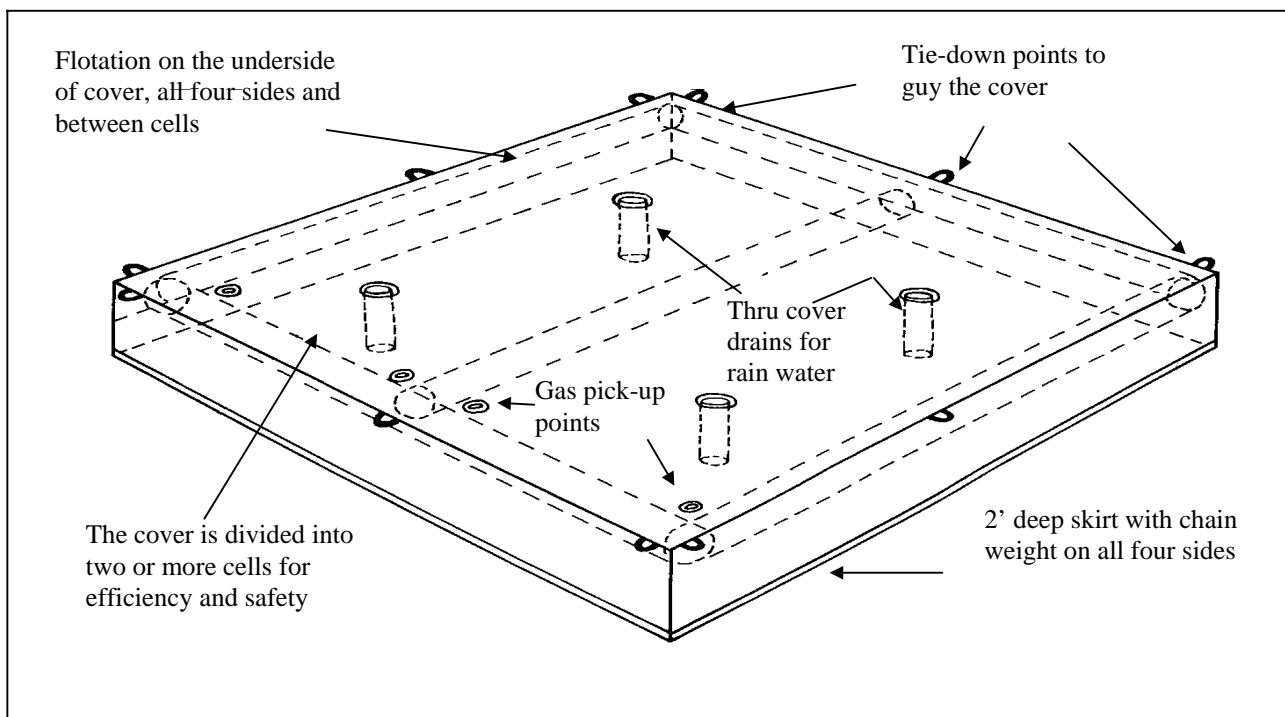
13 percent total solids. Swine manure cannot be treated with a plug flow digester due to its lack of fiber.

◆ **Fixed Film Digester.** Fixed-film digesters consist of a tank filled with plastic media. The media supports a thin layer of anaerobic bacteria called biofilm (hence the term "fixed-film"). As the waste manure passes through the media, biogas is produced. Like covered lagoon digesters fixed-film digesters are best suited for dilute waste streams typically associated with flush manure handling or pit recharge manure collection. Fixed-film digesters can be used for both dairy and swine wastes. However, separation of dairy manure is required to remove slowly degradable solids.

## 1-1.3 Effluent Storage

The products of the anaerobic digestion of manure in digesters are biogas and effluent. The effluent is a stabilized organic solution that has value as a fer-

**Exhibit 1-2** Floating Cover Module for Lagoon Application in Arid Regions



Courtesy of Engineered Textile Products, Inc.

tilizer and other potential uses. Waste storage facilities are required to store treated effluent because the nutrients in the effluent cannot be applied to land and crops year round.

The size of the storage facility and storage period must be adequate to meet farm requirements during the non-growing season. Facilities with longer storage periods allow flexibility in managing the waste to accommodate weather changes, equipment availability and breakdown, and overall operation management.

## 1-1.4 Gas Handling

A gas handling system removes biogas from the digester and transports it to the end-use, such as an engine or flange. Gas handling includes: piping; gas pump or blower; gas meter; pressure regulator; and condensate drain(s).

Biogas produced in the digester is trapped under an airtight cover placed over the digester. The biogas is removed by pulling a slight vacuum on the collection pipe (e.g., by connecting a gas pump/blower to the end of the pipe), which draws the collected gas from under the cover. A gas meter is used to monitor the gas flow rate. Sometimes a gas scrubber is needed to clean or “scrub” the biogas of corrosive compounds contained in the biogas (e.g., hydrogen sulfide). Warm biogas cools as it travels through the piping and water vapor in the gas condenses. A condensate drain(s) removes the condensate produced.

## 1-1.5 Gas Use

Recovered biogas can be utilized in a variety of ways. The recovered gas is 60 - 80 percent methane, with a heating value of approximately 600 - 800 Btu/ft<sup>3</sup>. Gas of this quality can be used to generate electricity; it may be used as fuel for a boiler, space heater, or refrigeration equipment; or it may be directly combusted as a cooking and lighting fuel. Chapter 3 provides more information on biogas use.

Electricity can be generated for on-farm use or for sale to the local electric power grid. The most common technology for generating electricity is an internal combustion engine with a generator. The predicted gas flow rate and the operating plan are

used to size the electricity generation equipment.

Engine-generator sets are available in many sizes. Some brands have a long history of reliable operation when fueled by biogas. Electricity generated in this manner can replace energy purchased from the local utility, or can be sold directly to the local electricity supply system. In addition, waste heat from these engines can provide heating or hot water for farm use.

Biogas can also be used directly on-site as a fuel for facility operations. Equipment that normally uses propane or natural gas can be modified to use biogas. Such equipment includes boilers, heaters, and chillers.

◆ **Boilers and Space Heaters.** Boilers and space heaters fired with biogas produce heat for use in the facility operations. Although this may not be the most efficient use of the gas, in some situations it may be a farm’s best option.

◆ **Chilling/Refrigeration.** Dairy farms use considerable amounts of energy for refrigeration. Approximately 15 to 30 percent of a dairy’s electricity load is used to cool milk. Gas-fired chillers are commercially available and can be used for this purpose. For some dairies, this may be the most cost effective option for biogas utilization.

Other energy use options may exist. For example, a nearby greenhouse could be heated with the biogas, and carbon dioxide from the heater exhaust could be used to enhance plant growth. These options need to be evaluated on a case-by-case basis.

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## 1-2. Benefits of Biogas Technology

Most confined livestock operations handle manure as liquids, slurries, semi-solids, or solids that are stored in lagoons, concrete basins, tanks, and other containment structures. These structures are typically designed to comply with local and state environmental regulations and are a necessary cost of production.

Biogas technology can be a cost-effective, environment and neighborhood friendly addition to existing

manure management strategies. Biogas technologies anaerobically digest manure, resulting in biogas and a liquefied, low-odor effluent. By managing the anaerobic digestion of manure, biogas technologies significantly reduce Biochemical Oxygen Demand (BOD), and pathogen levels; remove most noxious odors; and convert most of the organic nitrogen to plant available inorganic nitrogen.

The principal reasons a farmer or producer would consider installing a biogas system are:

- ◆ **On-Site Farm Energy.** By recovering biogas and producing on-farm energy, livestock producers can reduce monthly energy purchases from electric and gas suppliers.
- ◆ **Reduced Odors.** Biogas systems reduce offensive odors from overloaded or improperly managed manure storage facilities. These odors impair air quality and may be a nuisance to nearby communities. Biogas systems reduce these offensive odors because the volatile organic acids, the odor causing compounds, are consumed by biogas producing bacteria.
- ◆ **High Quality Fertilizer.** In the process of anaerobic digestion, the organic nitrogen in the manure is largely converted to ammonium. Ammonium is the primary constituent of commercial fertilizer, which is readily available and utilized by plants.
- ◆ **Reduced Surface and Groundwater Contamination.** Digester effluent is a more uniform and predictable product than untreated manure. The higher ammonium content allows better crop utilization and the physical properties allow easier land application. Properly applied, digester effluent reduces the likelihood of surface or groundwater pollution.
- ◆ **Pathogen Reduction.** Heated digesters reduce pathogen populations dramatically in a few days. Lagoon digesters isolate pathogens and allow pathogen kill and die-off prior to entering storage for land application.

Biogas recovery can improve profitability while improving environmental quality. Maximizing farm resources in such a manner may prove essential to

remain competitive and environmentally sustainable in today's livestock industry. In addition, more widespread use of biogas technology will create jobs related to the design, operation, and manufacture of energy recovery systems and lead to the advancement of U.S. agribusiness.

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### 1-3. The U.S. Biogas Experience

Rising oil prices in the 1970's triggered an interest in developing "commercial farm-scale" biogas systems in the United States. During this developmental period (1975-1990) approximately 140 biogas systems were installed in the United States, of which about 71 were installed at commercial swine, dairy, and caged layer farms.

Many of these initial biogas systems failed. However, learning from failures is part of the technology development process. Examining past failures and successes led to improvements and refinements in existing technologies and newer, more practical systems. The main reasons for the success and failure of biogas recovery projects follow.

#### 1-3.1 Reasons for Success

Biogas recovery projects succeeded because:

1. The owner/operator realized the benefits biogas technology had to offer and wanted to make it work.
2. The owner/operator had some mechanical knowledge and ability and had access to technical support.
3. The designer/builder built systems that were compatible with farm operation.
4. The owner/operator increased the profitability of biogas systems through the utilization and sale of manure byproducts. Some facilities generate more revenues from the sale of electricity and other manure byproducts than from the sale of milk.

### 1-3.2 Reasons for Failure

Biogas recovery projects failed because:

1. Operators did not have the skills or the time required to keep a marginal system operating.
2. Producers selected digester systems that were not compatible with their manure handling methods.
3. Some designer/builders sold “cookie cutter” designs to farms. For example, of the 30 plug flow digesters built, 19 were built by one designer and 90 percent failed.
4. The designer/builders installed the wrong type of equipment, such as incorrectly sized engine-generators, gas transmission equipment, and electrical relays.
5. The systems became too expensive to maintain and repair because of poor system design.
6. Farmers did not receive adequate training and technical support for their systems.
7. There were no financial returns of the system or returns diminished over time.
8. Farms went out of business due to non-digester factors.

This handbook draws from these lessons and provides a realistic screening process for livestock facilities to decide if biogas technology is an appropriate match for the farm and farm owner.

### 1-3.3 Today's Experiences

The development of anaerobic digesters for livestock manure treatment and energy production has accelerated at a very fast pace over the past few years. Factors influencing this market demand include: increased technical reliability of anaerobic digesters through the deployment of successful operating systems over the past decade; growing concern of farm owners about environmental quality; an increasing number of states and federal programs designed to cost share in the development of these systems; and the emergence of new state

energy policies designed to expand growth in reliable renewable energy and green power markets.

There are currently about 70 operating digester systems, with another 35 planned for construction in 2004. Six of these centralized systems provide manure treatment for surrounding farms. Currently, three centralized systems are operational and three more are planned. A methodology for assessing and reviewing centralized projects is discussed further in Chapter 9. More information on some of the operating digesters can be found in Appendix A.

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# Chapter 2      Preliminary Screening for Project Opportunities

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This chapter presents a preliminary screening process for livestock producers, developers, or others considering biogas recovery to determine if their livestock facility is a candidate for a biogas project. In general, facilities that collect large amounts of manure daily, or at least weekly, should consider biogas technology.

The screening criteria are as follows:

- 1. Is Your Confined Livestock Facility (Dairy or Hog) “Large”?** For screening purposes, livestock facilities with at least 500 head of dairy cows/steers or 2,000 sows or feeder pigs in confinement, where at least 90 percent of the manure is collected regularly, are potential candidates. Facilities of this size produce enough manure to generate the biogas required to support a financially viable project. It should be noted, however, that this size criterion is not absolute. Smaller confined facilities could potentially support successful recovery projects, given certain site-specific and market conditions.
- 2. Is Manure Production and Collection Stable Year-Round?** Animal facilities that have little variation in the daily confined animal populations have predictable manure production. This will ensure that a consistent amount of manure is available for collection year-round.
- 3. Is Your Manure Management Compatible with Biogas Technology?** Biogas technology requires the manure to be: managed as liquid, slurry, or semi-solid; collected at one point; collected regularly (daily or weekly); and free of large quantities of bedding and other materials (e.g., rocks, stones, sand, straw). Farms with such manure management practices provide an opportunity to install a biogas system.
- 4. Is There a Use for the Energy Recovered?** The potential to use the recovered biogas for energy plays a significant role in determining the cost-effectiveness of the biogas project. Both

on-farm energy requirements and the possibility of selling energy off-site should be considered. In general, any piece of equipment that uses propane or natural gas as a fuel source can potentially be operated using biogas.

- 5. Will You be Able to Manage the System Efficiently?** Biogas systems are a management responsibility. Efficient system management requires the owner/operator to:

1. pay regular attention to system operations;
2. provide necessary repair and maintenance; and,
3. have the desire to see the system succeed.

Each of the steps in the assessment is discussed in turn. This chapter concludes with a summary of the overall appraisal.

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## 2-1. Is the Confined Livestock Facility “Large”?

Confined animals produce collectable manure for digestion consistently all year round. Large livestock facilities generally produce enough manure to support a biogas project. Such farms have predictable biogas yields available to offset energy usage.

### 2-1.1 Is the Livestock Facility “Large”

Livestock facility size is a primary indicator of whether biogas recovery will be economically feasible.

Although there are many factors that influence biogas production from livestock manure, the amount of manure collected determines the amount of biogas that can be produced. The amount of manure produced by a livestock facility will be directly related to the number of animals in the facility. However, biogas can only be produced from fresh manure collected on a regular schedule, with a minimum amount of contamination. With this in mind, the number of animals (dairy cows or hogs) in a facility can be used as an indicator of whether that

operation generates, or has the potential to generate, a significant amount of biogas. The number of animals and proportion of the manure collected can be used to indicate whether more detailed technical assessments should be undertaken.

As a general rule of thumb, manure collection *equivalent* to the total daily manure production from **500 dairy cows or 2,000 sows or feeder pigs** is the minimum size to be considered. This rough estimate takes into account the general manure production rate and manure composition of these animals. This minimum value is not absolute. Other factors, such as climate, diet, value of energy, odor and other environmental concerns, and existing manure management system can affect this minimum value. The software tool, FarmWare contained in this handbook allows you to evaluate the impact of these factors in terms of farm costs and benefits.

## 2-1.2 Is Manure Production and Collection Stable Year Round?

In addition to a minimum number of animals from which manure is collected, candidate facilities should have relatively constant animal populations year round. This will ensure that a consistent amount of manure is available for collection year round. Knowing the amount of collectible manure is critical in sizing the digester and gas use components. If the daily manure produced is greater or less than the digester capacity, there will be addi-

tional costs of manure management or loss of revenues and/or savings from under-utilization.

For example, in a free-stall dairy where the animals remain confined in a free-stall barn throughout the year, manure can be collected consistently - allowing the digester to be fueled all year round. Alternatively, animals that are pastured in summer and housed in a barn in winter will not provide a steady supply of manure to the digester year round.

## 2-2. Is Your Manure Management Compatible with Biogas Technology?

Biogas production is best suited for farms that collect liquid, slurry, or semi-solid manure with little or no bedding regularly. This requires the facility to collect manure:

- ◆ as a liquid, slurry, or semi-solid;
- ◆ at a single point;
- ◆ every day or every other day;
- ◆ free of large amounts of bedding or other materials (e.g., rocks, stones, straw, sand)

These conditions ensure consistent digester feedstock and continued biogas production. Each condition is discussed in turn.

Exhibit 2-3 presents a simple checklist for manure

### Exhibit 2-1 Checklist for Facility Characteristics

1. Do you have at least 500 cows/steer or 2,000 pigs at your facility?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2. Are these animals in confinement all year round?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3. The average animal population does not vary by more than 20% in a year?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<p>If the answer is <b>YES</b> to all the above questions, your facility is in good shape. Proceed to the next section. If the answer is <b>NO</b> to one or more of the above questions, the production and utilization of biogas as a fuel may not be suitable for your facility. For biogas production and utilization to succeed, a continuous and relatively consistent flow of biogas is required. However, collecting and flaring biogas can reduce odors. Therefore, also proceed to the next section if you have the need for an effective odor control strategy.</p>		

management conditions favoring biogas technology.

## 2-2.1 What Type of Manure Is Collected?

Livestock facilities that collect manure as a liquid, slurry, or semi-solid are the best candidates for biogas recovery projects. At such facilities, farm operators will know the daily operational management requirements for these materials and it is likely that the manure can be digested to produce biogas.

Whether manure is handled as a semi-solid, slurry, or liquid at a particular facility depends on its total solids content. Exhibit 2-2 shows the manure characteristics and handling systems that are appropriate for specific types of biogas production systems.

Manure handled as a liquid has a total solids content of less than 5%; a manure slurry has a solids content of 5% to 10%; and semi-solid manure has a solids content of 10% to 20%. Liquid, slurry, and semi-solid systems have high biogas production potentials and offer substantial greenhouse gas reduction potential. These management systems are widely used on swine and dairy operations, and under some conditions can produce undesirable odor events. Drylot housing or manure packs produce manure with total solids above 25%. These high solid systems do not promote anaerobic conditions that lead to biogas production, and should not be considered as inputs

to a biogas system.

Facilities that handle solid manure will find it difficult to adopt biogas technology. They will need to incorporate a new manure handling system and routine. Such changes can be expensive. In these situations, other effective manure management options (e.g., composting) should be considered.

## 2-2.2 Is the Manure Collected at One Point?

Generally, most confined facilities collect manure at one point. Facilities that collect and deliver manure to a common point every day or every other day are better candidates for biogas technology. The common point may be a lagoon, pit, pond, tank, or other similar structure.

Collecting manure at a common point makes it easier to load the digester. At this point, the manure may be pre-treated before entering a digester. Pre-treatment adjusts the total solids content as required by digesters. This may include adding water, separating solids, manure mixing, or manure heating.

If the facility does not collect manure at a common point, you should assess the feasibility of altering current practices to do so. If there are only two or three points of collection, it may be possible to use a

**Exhibit 2-2** Appropriate Manure Characteristics and Handling Systems for Specific Types of Biogas Digester Systems

	Total Solids (%)						
	0	5	10	15	20	25	30
Manure	Water Added			Bedding Added			
	As Excreted						
Classification	Liquid	Slurry	Semi-Solid		Solid		
Handling Options	Pump		Scrape			Scrape and Stack	
Biogas Production	Recommended			Not Recommended			
Digester Type							
	Covered Lagoon or Fixed Film	Complete Mix	Plug Flow				

digester at the largest of these points.

## 2-2.3 Is the Manure Collected Daily or Every Other Day?

Manure is the feedstock for a digester system. While an occasional daily feeding of a digester might be missed with little consequence under normal operations, not feeding a digester for a week can lead to a loss of biogas production. More importantly, feeding the digester in irregular intervals can disrupt the biological process and cause the system to work inefficiently or stop entirely. Therefore, most digesters are designed to be fed daily. With continuous feed and discharge of material from the system, the bacteria work efficiently and higher volumes of manure are processed.

Daily manure collection is also efficient in terms of conserving the nutrient values of the manure and preserving its gas production potential. Any decomposition of organic material outside the digester will reduce biogas production. Therefore, it is best to feed fresh manure to a digester.

If you do not collect manure daily, you should consider converting to daily manure collection.

## 2-2.4 Is the Manure Free of Large Amounts of Bedding?

The manure should be free of large quantities of bedding and other materials such as sand, rocks, and stones. Only a small amount of bedding can be tolerated by most digesters.

Bedding materials (e.g., sawdust, straw) often end up in the manure. Clumps of bedding will clog influent and effluent pipes of the digester and hinder operation. Small amounts of bedding will not be a problem and minimizing bedding addition to digesters is relatively simple, in most cases.

Other materials such as feed additive including antibiotics and equipment cleaning and maintenance compounds (e.g., detergents, acids, halogens, etc.) may be harmful to anaerobic bacterial action. The typical use of these materials has not been found to be a problem in full scale digesters. However, threshold levels for these compounds have not been established, so operators should be careful not to release large quantities of such materials into the manure before it is fed to the digester.

## Exhibit 2-3 Checklist for Manure Management

1.	Do you collect manure as a liquid/slurry/semi-solid?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2.	Is the manure collected and delivered to one common point?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3.	Is the manure collected daily or every other day?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
4.	Is the manure sand relatively free of clumps of bedding and other material, such as rocks, stones, and straw?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<p>If the answer is <b>YES</b> to all the above questions, manure management criterion is satisfied. If the answer is <b>NO</b>, to any of the questions, you may need to change your manure management routine. See text.</p>			

### 2-3. Is There a Use for Energy?

The most cost effective biogas projects are those where the energy in the biogas can be used or sold. In many cases, the value of the energy produced from the gas can more than offset the cost of collecting and processing the gas, thereby making the project cost effective on its own. The purpose of this step is to assess whether it is likely that there are suitable uses for the gas recovered from the live-stock facility manure.

There are two main gas use options: (1) generation of electricity for on-site use or sale to the power grid; and (2) direct use of the gas locally, either on-site or nearby.

The biogas can be used to fuel a reciprocating engine or gas turbine, which then turns a generator to generate electricity. Modern mechanized dairies and swine facilities typically require a significant amount of electricity to operate equipment. For example, dairies operate vacuum pumps, chillers, feed mixers, and fans. Swine facilities typically operate heat lamps and ventilation equipment. If the electricity is not required on-site, it could be sold to the local power grid.

On-farm use of the gas is often simple and cost-effective. The biogas can be used to fuel boilers or heaters, and in most processes requiring heat, steam, or refrigeration. Dairies and swine farms generally require hot wash water for cleaning and other operations. However, most farms can produce far more gas than they require to replace on-site gas

needs.

Other energy use options may present themselves on a case-by-case basis. For example, a specialized need for gas nearby, or a simple flare may be used to control odor and reduce greenhouse gas emissions. Exhibit 2-4 presents a checklist to assess whether energy use options are likely to exist.

### 2-4. Can You Manage a Biogas System Effectively?

Good design and management is key to the success of a biogas system. Many systems have failed because operators did not have the technical support, the time, the skills, or the interest required to keep the system operating. The owner should realize that a digester requires regular attention, but not much time. If the owner is committed to seeing a digester succeed, generally it will. Effective management requires the following:

- ◆ **Technical Support.** There are key components of a digester system with which the owner must become familiar. Operation and maintenance of the digester and biogas use system should be taught by the designer to the owner. Competent technical support from the digester designer or a designer consultant may be needed occasionally to solve rare or unusual problems.
- ◆ **Time.** System operation requires a time commitment. Daily maintenance and monitoring of

**Exhibit 2-4** Checklist for Energy Use

1. Are there on-site uses (e.g., heating, electricity, refrigeration) for the energy recovered?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2. Are there facilities nearby that could use the biogas?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3. Are there electric power distribution systems in your area that could or do buy power from projects such as biogas recovery?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<p>If the answer is <b>YES</b> to any of the above questions, the energy use criterion is satisfied for initial screening purposes.</p>		

a system require approximately 15-30 minutes. Additionally, infrequent blocks of time for repair and preventive maintenance are required. The time required for these tasks ranges from approximately 10 minutes to 10 hours, with most maintenance tasks requiring 30 minutes to 2 hours. The need for (and lack of) infrequent major repairs has led to the failure of many systems.

- ◆ **Technical skills.** A biogas system will require some maintenance. In addition to the general mechanical skills found at most farms, an individual skilled in engine repair and maintenance is invaluable. This does not imply that a full-time mechanic is required. Rather, an individual with some mechanical knowledge and ability is sufficient. Typical skills required include engine repair, maintenance, and overhauls; troubleshooting and repair of electrical control problems; plumbing; and welding. Additionally, repair parts and services should be easily accessible. These services are often available through equipment dealers. Access to these services is an important consideration when making a deci-

sion on equipment purchases.

- ◆ **Desire.** The owner must accept the system as his/her own and want to operate it. Owners should understand how the technology works and be committed to seeing the system succeed. Systems where the management was left to seasonal farm labor or third parties often failed because of lack of motivation and incentive.

In the ideal management scenario, a trained person would spend approximately 30 minutes to 1 hour a day operating the system. This person would understand the fundamentals of anaerobic digestion and would be involved in the operation and maintenance of the system. Additionally, this person would possess the technical acuity to understand and operate mechanical equipment. Ideally, this person would be part of the planning and construction of the system. In cases where the operator is not the owner, operating incentives such as bonuses based on system “up time” may be considered.

---

### Exhibit 2-5 Checklist for Management

- |  |                              |                             |
|--|------------------------------|-----------------------------|
| 1. Is there a “screw driver friendly” person on the farm that can operate and maintain the technical equipment?                      | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 2. If YES, can this person spend about 30 minutes a day to manage the system and 1 to 10 hours on occasional repair and maintenance? | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 3. Will this person be available to make repairs during high labor use events at the farm?   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 4. Is technical support (access to repair parts and services) available?   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |
| 5. Will the owner be overseeing system operations?   | Yes <input type="checkbox"/> | No <input type="checkbox"/> |

If the answers are **YES** to the above questions, the management criterion is satisfied.  
In general, if the owner is committed to seeing the system succeed, it will.

## 2-5. Initial Appraisal Results

Using the information from the above four steps, the initial appraisal can be performed. Exhibit 2-6 lists the questions addressed by the four steps.

Even if one or more questions cannot be answered "Yes," there may be opportunities for biogas recovery under certain circumstances.

### Special Conditions

The following types of special conditions would favor gas recovery from livestock manure facilities:

- ◆ **Severe Odor Problems.** At some farms, the odors associated with livestock manure impair air quality, are a nuisance to neighbors, and may become grounds for lawsuits. In areas where odor related problems are significant, the installation of a biogas recovery system will be favored, as it removes offensive manure odors. Using digesters primarily for odor control is cost-effective if the costs of not controlling odor are substantial.

- ◆ **Environmental Problems.** The Federal Clean Water Act requires zero discharge of contaminated run-off because manures are a source of agricultural pollution, affecting waterways, soil, and groundwater. Biogas recovery systems can help reduce this pollution by giving the owner a point of control and revenue from manure management.

- ◆ **High Energy Cost.** High energy costs favor biogas recovery projects. In high cost environments (e.g., electricity costing more than \$0.08 per kWh), smaller sites (e.g., 200 cows) could potentially support profitable gas recovery projects.

- ◆ **High Cost of Commercial Fertilizer.** High costs of commercial fertilizers favor biogas recovery projects. In the process of biogas recovery, the organic nitrogen content of the manure is largely converted to ammonium, a higher value and more predictable form of plant available nitrogen.

**Exhibit 2-6** Initial Appraisal Results Checklist

1.	Are there at least 500 cows/steers or 2,000 hogs in confinement at your facility year round?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2.	Is your manure management compatible with biogas technology?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3.	Can you use the energy?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
4.	Can you be a good operator?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<p>If the answer is <b>YES</b> to all questions, there are promising options for gas recovery. Proceed to Chapter 3, where the project technical and economic feasibility will be determined. If you answered <b>NO</b> to any of the questions, you may need to make some changes. Read the relevant section, evaluate the cost of changes required, if any, before proceeding.</p>			

- ◆ **Compost, Potting Soil, and Soil Amendment Markets.** Digested dairy manure solids can be used to replace purchased bedding or can be sold alone and in mixes for potting soil and garden soil amendments. Regional markets exist for soil products. Digested solids have been sold to wholesale and retail customers.
  
- ◆ **Niche Applications.** Options for utilizing the by-products of anaerobic digestion may present themselves. For example, the digester effluent may be used to stimulate the growth of algae in fishponds and thereby provide feed for fish. These niche options must be evaluated on a case-by-case basis.

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# Chapter 3      Selecting a Gas Use Option

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The purpose of this chapter is to examine how biogas can be used at a farm. Electricity generation with waste heat recovery (cogeneration) is usually the most profitable option for a farm. However, other options may be profitable in certain circumstances. This chapter serves as a reference to determine what factors need to be considered when determining how to use the biogas.

There are several important factors to be considered when selecting a biogas use option:

- ◆ **What type of energy does the farm use?** Farms use electricity, natural gas, propane, or fuel oil energy. Biogas can be used to replace purchased energy for electricity, heating, or cooling. For most farms, the most profitable biogas use option will be to fuel an internal combustion (IC) engine or gas turbine driven generator to produce electricity. Other options include using biogas to fuel forced air furnaces, direct fire room heaters, and adsorption chillers.
- ◆ **How much energy does the farm use and when?** Farm energy requirements will vary daily and seasonally. For example: heating and air conditioning are seasonal uses; most lighting is used at night; milking two or three times a day for four hours is a very uneven use of electricity; and hog barn ventilation varies by the time of day and season. Most farm operations have the potential to produce most or all their energy needs if they collect and convert all suitable manure produced to biogas.
- ◆ **Will the potential energy production offset energy needs?** When matching biogas availability to energy requirements, it is important to keep in mind that biogas is produced year round and biogas storage for more than several hours is expensive. Therefore, the most cost-effective biogas use option is one that uses the gas year round. Direct gas use options, such as space heating and cooling, vary seasonally. Furthermore, these options can use only a small fraction of the potential energy from biogas. Designing a system for such a limited use will generally not be cost effective, unless the system is for purposes of odor control. Large farms may be able to match biogas energy production more closely to energy use than will small farms.

- ◆ **Is electricity the primary energy requirement?** In the United States, electricity is the largest stationary use of energy on farms. Electric motors for pumps, fans, and motors, as well as lights are generally in use all year round. Usually electricity production for on-farm use is the most viable option.
- ◆ **Can the engine generator be serviced?** Easy access for maintenance tasks and ready availability of parts and services are critical considerations.

The potential gas use options are discussed in turn and summarized in Exhibit 3-1.

For further discussion of gas use options, review *The Handbook of Biogas Utilization*, available from General Bioenergy, P.O. Box 26, Florence, Alabama 35631, Phone: (256) 740-5634.

**Exhibit 3-1** Summary of Potential Gas Use Options

Option	Applicability
Electricity Generation	Suitable for most facilities (electricity accounts for approximately 70 to 100% of energy use).
Direct Combustion	
Boiler/Furnace	Seasonal use or specialized situations
Chiller	Dairy refrigeration (approximately 15 to 30% of dairy electricity use); seasonal cooling; and specialized situations

### 3-1. Electricity Generation

Electricity can be generated for on-farm use or for sale to the local electric power grid. Modern dairies and swine facilities require a significant amount of electricity to operate equipment. Hog nurseries require a large amount of circulating heat, but few have hot water heat. Almost all use electric heat lamps and supplemental propane heaters to maintain a suitable temperature. Similarly, 30 percent of dairy electricity consumption is used to cool milk.

The most commonly used technology for generating electricity is an internal combustion engine with a generator. Recovering waste heat from these engines can provide heating, hot water for farm use, or hot water for digester heating thereby improving the overall energy efficiency of the system.

#### 3-1.1 Electricity Generation System Components

Typical electricity generation systems consist of: (1) an IC engine or gas turbine; (2) a generator; (3) a control system, and (4) an optional heat recovery system. Each component is discussed briefly, in turn.

1. **IC Engine or Gas Turbine.** Both IC engines and gas turbine driven generators sets are being used to generate electricity from biogas.

- ◆ *IC Engine.* Natural gas or propane engines are easily converted to burn biogas by modifying carburetion and ignition systems. Natural gas engines are available in virtually any capacity that is required. The most successful engines are industrial natural gas engines that can burn wellhead natural gas. A biogas fueled engine generator will normally convert 18 - 25 percent of the biogas BTUs to electricity, depending on engine design and load factor. Gas treatment is not necessary if proper maintenance procedures are followed. Biogas engines less than 200 horsepower (150 kW) generally meet the most stringent California pollution restrictions without modification if run with a lean

fuel mixture. Exhibit 3-2 shows a typical engine-generator set.

- ◆ *Gas Turbines.* Small gas turbines that are specifically designed to use biogas are also available. An advantage to this technology is lower NOx emissions and lower maintenance costs, however energy efficiency is less than with IC engines and it costs more.
2. **Generator.** There are two types of generators that are used on farms: induction generators and synchronous generators.

- ◆ *Induction Generator.* An induction generator will operate in parallel with the utility and cannot stand alone. Induction generation derives phase, frequency, and voltage from the utility. Negotiations with a utility for interconnection of a small induction generator are generally much easier.

- ◆ *Synchronous Generator.* A synchronous generator will operate either isolated or in parallel. The synchronous generator can provide electricity to the farm if the utility is shut down. Synchronous parallel generation requires a sophisticated interconnection to match generator output to utility phase, frequency, and voltage. This is typically more expensive than controls for an induction generation.

Most farm-scale systems will use induction generators. The options for electricity generation modes (isolated versus parallel) are discussed further in Section 3-1.2.

3. **Control System.** Controls are required to protect the engine and to protect the utility. These systems are well developed. Control packages are available that shut the engine off due to mechanical problems such as high water temperature or low oil level. The control system will also shut off the engine if the utility power is off, or if utility electricity is out of its specified voltage and frequency range. It is important to recognize that the control system selected must be designed to operate in a damp environment where corrosive gases, such as ammonia, may be present.

4. **Waste Heat Recovery.** Approximately 75 percent of fuel energy input to an engine is rejected as waste heat. Therefore, it is common practice to recover engine heat for heating the digester and providing water and space heat for the farm. Commercially available heat exchangers can recover heat from the engine water cooling system and the engine exhaust. Properly sized heat exchangers will recover up to 7,000 BTUs of heat per hour for each kW of generator load, increasing energy efficiency to 40 - 50 percent.

### 3-1.2 Electricity Generation Options

A farm may choose to use a stand-alone engine-generator to provide all or part of its own electricity as an "isolated" system (disconnected from the utility). It may also operate connected to and interfacing electricity with the utility, "in parallel". Most farms will opt for parallel power production.

- ◆ **Isolated Power Production.** An isolated system must be able to function continuously, without interruption, to meet fluctuating levels of electricity demand while maintaining a smooth and steady 60 cycle current. Varying electric loads or large motor starting loads can lead to drift in the 60 cycle current. Drift results in wear on the motors, speed up or slow down of clocks and timers, and operating problems with computers and programmable logic controllers.

Isolated systems require a sophisticated control system and a gas reservoir to meet changing loads. They are generally oversized to accommodate the highest electrical demand while operating less efficiently at average or partial load.

The primary advantage of an isolated power production system is that it is free from the utility.

The disadvantages of isolated power production include: (1) having to operate and maintain the system at all times; (2) purchasing oversized and costly equipment, if high quality electricity is needed; (3) purchasing and maintaining a backup generation system or paying the utility for backup service, if electricity is critical to farm operations; (4) requiring an engine that is

sized to meet maximum farm load (varying load means that the engine has to increase or decrease output implying that the engine is operating inefficiently); and (5) managing electricity use to reduce demand fluctuations.

- ◆ **Parallel Power Production.** A parallel system is directly connected to the utility and matches the utility phasing, frequency and voltage so the farm produced electricity blends directly with the utility line power. A utility interconnection panel with safety relays is required to operate in parallel and to disconnect the farm generator if there is a problem with either utility or farm generation.

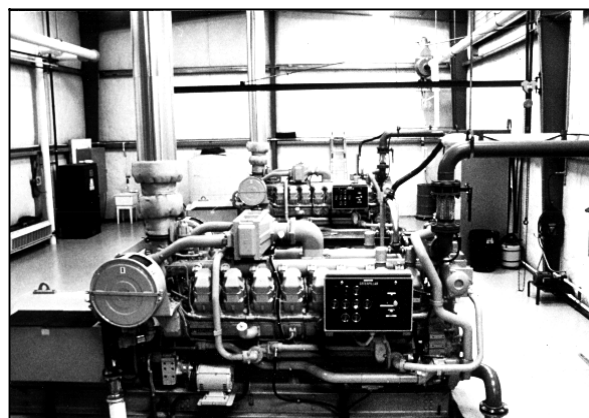
Parallel operation allows the farm generator to run at a constant output regardless of farm demand. Constant output allows more efficient use of biogas and less wear on the engine. The engine-generator can be sized for the biogas availability as opposed to farm requirements.

The farm buys power when under-producing and sells power when overproducing. The utility is the backup system if engine maintenance is required.

The key issue in developing a profitable biogas recovery system is the value of the energy to the owner. A careful review of utility rates and interconnection requirements are necessary prior to selecting the operating mode. Rate negotiation is appropriate for farm scale projects as most rules are set

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**Exhibit 3-2** Typical Engine-Generator Set



up for very large independent power producers. Chapter 5 discusses how a livestock producer should negotiate with a utility. FarmWare can help you understand the impact of utility rates on electrical costs and expected revenues from the project.

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### 3-2. Direct Combustion

The recovered biogas can be used directly on-site as a fuel. Equipment that normally uses propane or natural gas such as boilers, forced air furnaces, and chillers, can be modified to use biogas. Typical farms use only a limited amount of these fuels compared to electricity.

#### 3-2.1 Heating

Heating is usually a seasonal operation. Boilers and forced air furnaces can be fired with biogas to produce heat. Although this may be an efficient use of the gas, it is generally not as convenient as electricity. Nevertheless, in some situations it may be a best option.

◆ **Boilers.** Thousands of biogas-fired boilers are in use at municipal waste treatment plants in the United States, where they provide hot water for building and digester heat. Conversion efficiencies are typically at 75 to 85 percent. Several have been installed on farm digesters. Farms require hot water year round, but there is typically more biogas available than hot water required. Farrow to wean and farrow to nursery hog farms in cold climates are the only type of farm where heat requirements could consume most or all of the available biogas production potential. Exhibit 3-23 shows.

A cast iron natural gas boiler can be used for most farm applications. The air-fuel mix will require adjustment and burner jets will have to be enlarged for medium BTU gas. Cast iron boilers are available in a wide range of sizes, from 45,000 BTU/hour and larger. Untreated biogas can be burned in these boilers. However, all metal surfaces of the housing should be painted. Flame tube boilers with heavy gauge flame tubes may be used if the exhaust temperature is maintained above 300°F to minimize

condensation. High hydrogen sulfide ( $H_2S$ ) concentration in the gas may result in clogging of flame tubes.

◆ **Forced Air Furnaces.** Forced air furnaces could be used in hog farms in place of direct fired room heaters, which are commonly used in hog farrowing and nursery rooms. A farm will typically have multiple units. Biogas fired units have not been installed in the United States due to a number of reasons. These heaters are available and in use in Taiwan.

#### 3-2.2 Chilling/Refrigeration

Dairy farms use considerable amounts of energy for refrigeration. Approximately 15 to 30 percent of a dairy's electricity load is used to cool milk. Gas-fired chillers are commercially available and can be used for this purpose. For some dairies, this may be the most profitable option for biogas utilization.

Gas-fired chillers produce cold water for milk cooling or air conditioning. Dairies cool milk every day of the year. Chilled water or glycol can be used in milk precoolers in place of well water. Units are under development that should produce glycol at temperatures less than 30°F and allow direct refrigeration. A dairy generally requires 0.014 tons of cooling per hour of milking per cow per day. This is about 15 percent of the potential biogas production

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**Exhibit 3-3** Hot Water Mats Replace Heat Lamps in Farrowing Buildings for Additional Energy Savings



from the same cow (one ton of cooling = 12,000 BTU/hour).

Double effect chillers, producing hot and cold water simultaneously, are available for applications of over 30 tons and could be coupled with a heated digester.

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# Chapter 4      Technical and Economic Feasibility Assessment

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The purpose of this chapter is to lead you through the technical and economic feasibility assessment of biogas technology at a facility. This process involves several steps. First, the compatibility of existing manure management practices with potential digester types is examined. Then site-specific data are collected using evaluation forms. These data are entered into FarmWare, the decision support software developed by AgSTAR. It will perform the technical and economic feasibility analyses. Finally, the results from FarmWare are evaluated and a final appraisal of project opportunities is performed.

It is expected that the owner/operator or the person most knowledgeable about the facility will be collecting data and performing this assessment. In some areas, NRCS may be contacted for assistance. See Appendix B for a list of contacts. Checklists and screening forms have been provided to assist you through the process. Additionally, sample case studies have been presented in Appendix E to assist you further.

To select an appropriate and cost effective biogas technology option(s), complete the following steps:

1. **Match a Digester to Your Facility.** Whether a digester can be integrated into a facility's existing or planned manure management system depends on the climate and solids content of the manure. Section 4-1 discusses this step in more detail.
2. **Complete Evaluation Forms.** These forms record the information required to complete the FarmWare assessment. A separate form is provided for swine and dairy facilities. Section 4-2 presents the screening forms and necessary directions.
3. **Enter Information into FarmWare.** The information from Step 2 is entered into FarmWare, the decision support software provided with this handbook (Appendix C). Section 4-3 discusses this step in more detail.
4. **Evaluate Results.** Using the results from the FarmWare analyses, a final appraisal of project opportunities can be performed. This process is presented in Section 4-4.

Each step is discussed in turn.

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## 4-1. Match a Digester to Your Facility

The choice of which digester to use is driven primarily by the climate and characteristics of the existing manure management system, in particular how the system affects the total solids content of the manure.

As mentioned in Chapter 1, one of four digester types will be suitable for most manure management conditions: covered lagoon; complete mix digester; plug-flow digester, and fixed film.

- ◆ **Covered Lagoon Digester.** Covered lagoons require warm climates to be cost effective unless odor management is the goal. They can be used to treat liquid manure with up to 3 percent total solids.
- ◆ **Fixed Film Digester.** Fixed film digesters are best suited for use in warm climates. They can treat liquid manure with up to 3 percent total solids after removal of coarse solids by settling or screening.
- ◆ **Complete Mix Digester.** Complete mix digesters are applicable in all climates. They can treat manure with total solids in the range of about 3 to 10 percent.
- ◆ **Plug Flow Digester:** Plug flow digesters are applicable in all climates. They can treat only dairy manure with a range of about 11 to 13 percent total solids.

This section will help you decide which digester is suitable for your facility. First, the digesters appropriate for the climatic conditions at your facility are identified. Then the process of determining the total solids content of the manure is presented. Using the information from the first two steps, the digester appropriate for your facility is determined. The table presented in Exhibit 4-4 outlines this selection process.

### 4-1.1 Where Is The Facility Located?

Temperature is one of the major factors affecting the growth of bacteria responsible for biogas production. Biogas production can occur anywhere between 39° and 155°F (4° to 68°C). As the temperature increases, the gas production rate also increases, up to a limit.

Complete mix digesters and plug flow digesters are usable in virtually all climates. Plug-flow digesters and complete-mix digesters use supplemental heat to ensure optimal temperature conditions in the 95° to 130°F range (35° to 55°C). Capturing waste heat from a generator set is the preferred method for heating these types of digesters.

Covered lagoons generally do not use supplemental heat because there is not enough waste heat available to heat the large volume of dilution water. Lagoons require large capacities to treat the liquid manure properly at low temperatures; providing heat for these large capacities is expensive and usually not cost-effective. Therefore, covered lagoons for energy recovery are feasible only in moderate to

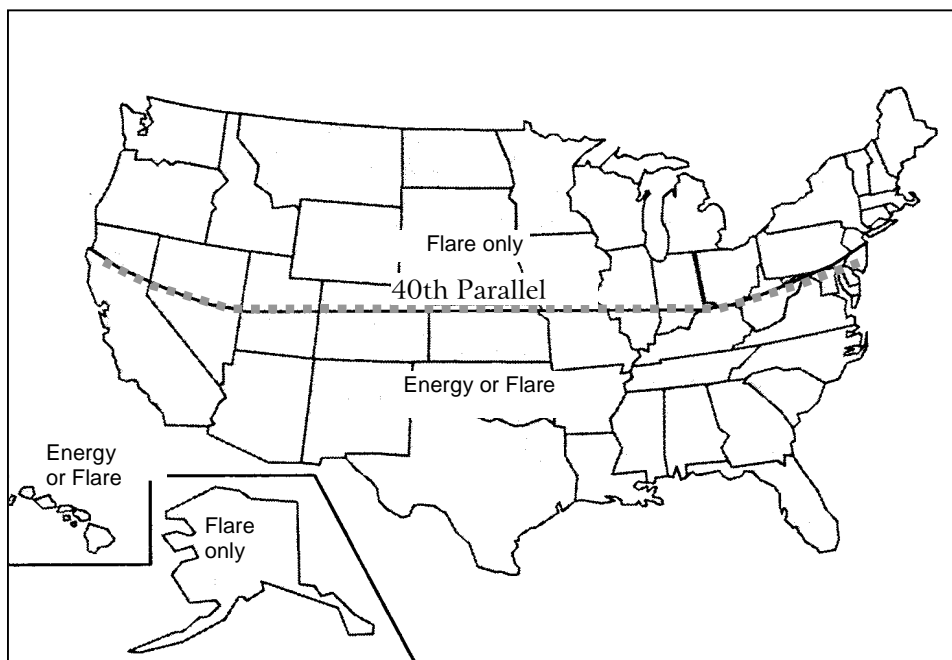
warm climates, where additional heat will not be required.

However, covered lagoons may be considered for use as an odor management and greenhouse gas reduction system in colder climates. Since gas production varies by season, covered lagoons in colder climates should be equipped with a simple flare system to combust the biogas produced in the lagoon. Flared gas makes a strong odor management statement. However, flaring available gas does not guarantee odor free manure availability for crop applications. Manure characteristics during crop application events are dependent upon lagoon sizing and operational parameters.

To determine which regions have a climate warm enough to install a covered lagoon for energy use, experts use a simple rule of thumb. Facilities in regions below the line of climate limitation (shown in Exhibit 4-1) should be warm enough to consider recovering biogas for energy use. In regions north of the line of climate limitation, sustaining the necessary temperature for the cost effective recovery of biogas, for energy use from covered lagoons, will

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**Exhibit 4-1** Covered Lagoons for Energy Recovery – Locations for Energy Production Generally Fall Below the 40<sup>th</sup> Parallel



Source: NRCS, *Anaerobic Digester, Ambient Temperature: Practice Standard No. 365*, 2003.

not be cost effective in most cases.

### 4-1.2 What Is the Total Solids Content of the Manure?

The total solids (TS) content of the collected manure is another controlling factor in determining which digester to use. TS content, usually expressed as a percentage, indicates the fraction of the total weight of the manure that is not water.

TS content depends on the animal type and the manure management strategy. The animal physiology and feed regimen determines the “as excreted” TS content. Manure “as excreted” may have a total solids content from 9 to 25 percent, depending on the animal type. This percentage may be increased by air drying or the addition of materials such as bedding. Adding fresh water, waste water, or recycle flush water lowers the TS content of collected manure.

### What is the Raw Manure Total Solids Percentage?

The “as excreted” solids value of raw manure for an animal is an average value established by research. Since different animals have different diets, the solids content of their manure - as excreted - differs within a range.

Exhibit 4-2 presents the solids content of manure for various animal types.

**Exhibit 4-2** Typical as Excreted Values

Animal Type	Total Solids (%)
Swine	9.2 – 10.0
Beef	11.6 – 13.0
Dairy	11.6 – 12.5
Caged Layers	25
<i>Source: NRCS, Agricultural Waste Management Field Handbook, 1998.</i>	

### How do the Waste Management Practices affect Manure Total Solids Percentage?

Common waste management practices that decrease and increase manure solids are briefly discussed below. Exhibit 4-3 shows the manure characteristics and handling systems that are appropriate for specific types of biogas production systems.

#### *Practices that Decrease Solids Concentration*

Water dilutes manure. The addition of water to manure may be deliberate (e.g., process water addition) or incidental (e.g., rainfall). Since the TS percentage is the controlling factor in determining which digester to use, knowing the extent of dilution of the solids by water is important. Excess water and increased waste volume can limit the capacity of manure handling and storage facilities. All water entering the waste management system must be accounted for in designing the digester system.

- ◆ **Process (Fresh) Water Addition:** Process water dilutes manure solids. In dairies, process water from the milking parlor is the largest new source of liquids reaching the manure management system. Most hog farms spend several days a week washing buildings for sanitation purposes. Water sprays or misters are often used for cooling hogs and cows and may contribute process water. Hogs waste water when drinking or when playing with hog waterers. These practices contribute 1 to 4 gallons of fresh wastewater per gallon of hog manure added to the collection system.
- ◆ **Flush or Pit Recharge Manure Collection:** Manure may be collected in hog or dairy buildings using recycle flush systems. Hog farms may use a pit recharge collection where 4 to 12 inches of fresh or lagoon recycle water is kept under the floors of the hog building and replaced every week or two. Small farms may use a daily hose wash. Flush collection dilutes fresh manure but delivers fresh volatile solids daily to a lagoon. If all manure is collected daily, then there is no loss of digestible volatile solids. Pit recharge delivers somewhat older manure to a lagoon, with some loss of digestibility. Manure

that is collected by flush removal is diluted to less than 2% total solids. Careful management of pit recharge systems may allow collection of manure with up to 3% total solids.

- ◆ **Rainfall Dilution:** Manure left on feedlot or open lots during rainfall will be diluted, resulting in lower solids.

Because the quantity of water added to manure varies among farms, dilution should be evaluated on a site specific basis. Simple ratios of water to manure added are presented in Exhibit 4-4 for different manure handling routines. These are the default values used in FarmWare if no other values are given.

#### *Practices that Increase Solids Concentration*

- ◆ **Dry Matter Addition:** Solids content of raw manure may be increased by the addition of straw, sand, and sawdust bedding. Bedding materials are generally dry and used to absorb manure liquids. These practices result in solid manure managed by solid manure equipment such as flail manure spreaders.
- ◆ **Sun Drying of Dry Lot and Corral Manure:** Manure drying in the sun will have a higher to-

tal solids percentage. Often indigestible dirt or stones are collected with corral manure. Manure begins to significantly decompose after one week and is probably not worth collecting for digestion. Typically, these practices are not compatible with biogas utilization strategies, and other waste management options should be considered.

#### 4-1.3 Summary Appraisal

Section 4-1.1 outlined why location was important; Section 4-1.2 described the impacts of manure management practices on manure solids. Using the information from the above two steps, an appropriate digestion technology can be selected for your facility.

Exhibit 4-4 presents a simple table that outlines the digester selection process. Facility operators may use this table to determine which digester is best suited for the farm. This information should not be used in place of the FarmWare water use inventory worksheet.

**Exhibit 4-3** Appropriate Manure Characteristics and Handling Systems for Specific Types of Biogas Digester Systems

	Total Solids (%)						
	0	5	10	15	20	25	30
Manure	Water Added			Bedding Added			
	As Excreted						
Classification	Liquid	Slurry	Semi-Solid		Solid		
Handling Options	Pump		Scrape			Scrape and Stack	
Biogas Production	Recommended			Not Recommended			
Digester Type							
	Covered Lagoon or Fixed Film	Complete Mix	Plug Flow				

**Exhibit 4-4** Matching a Digester to Your Facility

Climate†	Animal Type	Collection System	Estimated Min. Ratio of Water:Manure*	%TS	Digester Type
Moderate to Warm	Dairy	Flush	10:1	< 3%	Covered Lagoon Fixed Film
		Scrape & Parlor Wash Water	4:1 - 1.1:1	3% - 11%	Complete Mix
		Scrape - Manure Only	N/A	> 11%	Plug Flow
	Swine	Flush	10:1	< 3%	Covered Lagoon Fixed Film
		Scrape	2:1	3% - 6%	Complete Mix
		Pull Plug	5:1	< 2%	Covered Lagoon
		Managed Pull Plug	3:1	3% - 6%	Complete Mix
Cold	Dairy	Flush	10:1	< 3%	Limited possibility for Covered Lagoon
		Scrape & Parlor Wash Water	4:1 - 1.1:1	3% - 8%	Complete Mix
		Scrape - Manure Only	N/A	> 11%	Plug Flow
	Swine	Flush	10:1	< 3%	Limited possibility for Covered Lagoon
		Scrape	2:1	3% - 8%	Complete Mix
		Pull Plug	5:1	< 3%	Limited possibility for Covered Lagoon
		Managed Pull Plug	3:1	3% - 6%	Complete Mix

† The moderate to warm is the region below the 40<sup>th</sup> parallel and cold is the region above the 40<sup>th</sup> parallel (see Exhibit 4-1).  
 \* These ratios are default estimates used in FarmWare.

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## 4-2. Complete Evaluation Forms

Evaluation forms are provided starting on pages 4-8 for recording the site-specific information required by FarmWare to complete the technical and economic feasibility assessment. Forms have been provided for both dairy and swine facilities. It is suggested that additional copies of these forms be made prior to completing them.

Each form contains the following five sections:

1. **Climate Information.** Enter the location (state and county) of the facility.
2. **Farm Type.** Enter the farm type, farm size, manure collection method, and manure treatment method.
3. **Livestock Population.** Enter the number of animals on the farm by animal type.
4. **Manure Management.** Enter information on the manure management routine of the farm.
5. **Energy Information.** Enter the overall energy rates, by season, as well as the monthly breakdown of electricity and propane costs. Appendix G contains a sample letter to a utility requesting a monthly billing history and rate schedules and should be submitted for accurate figures.

These forms should be completed by the person most knowledgeable about the facility. It is expected that this person will also be completing the FarmWare analysis.

The evaluation is only as good as the accuracy of the input information. It may be useful to run FarmWare several times and change the inputs to see the effects on the output.

For assistance in completing the screening forms or using FarmWare call 1-800-95AgSTAR. The National Resource Conservation Service (NRCS) may be of assistance in completing the evaluation forms. See Appendix B for a list of NRCS contacts in your area. AgSTAR participants may elect to mail com-

pleted screening forms to the AgSTAR program. The AgSTAR program representative will conduct the FarmWare assessment and report the results of the assessment via mail. Please fill in a contact phone number in case a representative needs to verify information.

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## 4-3. Enter Information into FarmWare

FarmWare is a computer software package that enables owners, operators, or others investigating biogas technology as a manure management option to survey their facility, assess energy options, and evaluate system financial performance.

To use FarmWare, you must have an IBM compatible computer with the following features:

- ◆ A Pentium processor
- ◆ At least 128MB RAM (256MB RAM is recommended);
- ◆ Windows 98 or later; and
- ◆ At least 50 MB of hard disk space.

The FarmWare manual is included in Appendix C. The manual will guide you through the installation and use of FarmWare.

After installing the program, open FarmWare, and following the manual, input the data you recorded in the evaluation form.

Additionally, two case studies showing FarmWare analysis procedures have been presented for your reference in Appendix E. The first group of case studies is for dairy facilities. The next group is for swine facilities. These studies are examples of typical production facilities and waste handling strategies encountered at dairy and swine facilities. The case studies presented include:

### Dairy Case Study

1,200 Cow Flush Barn with Scraped Outdoor Lot

Baseline Waste Management System:

- Storage Pond
- Manure Stack

Biogas Waste Management System:

- Covered Lagoon Digester
- Manure Stack

### Swine Case Study

1,400 Sow Farrow-Finish Farm with Pit Recharge Barn.

Baseline Waste Management System:

- Anaerobic Lagoon

Biogas Waste Management System:

- Covered Lagoon Digester

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## 4-4. Evaluate Results

Project economics depend on a number of site specific factors, such as the details of the manure management system, farm energy needs, energy billing, and regulatory requirements. These factors affect the potential amount and quality of recoverable methane and consequently affect the potential revenues (or savings).

FarmWare estimates the costs and revenues from the project and presents the results in the *Quick Financial Report* screen. This screen also shows results for the three main techniques for assessing the economic feasibility of the project:

- ◆ **Payback Method.** The payback method involves determining the number of years it would take for a project to generate profits equal to the initial capital outlay. This method may be particularly suitable where there is a great amount of risk and uncertainty associated with a project

and the emphasis is on recovering capital expenditure as quickly as possible. The main disadvantages of this method are: it does not consider the costs and benefits that accrue at the end of the payback period; and it takes no account of the time when costs are incurred or benefits are received. The payback method is appropriate to use when making a rough preliminary assessment of a project's economic feasibility.

- ◆ **Discounted Cash Flow Method (Net Present Value).** The basic premise of the discounted cash flow technique is that costs or benefits occurring in the future are worth less than those occurring now. This means that annual costs and benefits are not simply added up over the years of the project. The costs and benefits in each year of the project are adjusted by a discount factor so that costs or benefits occurring in one year can be compared with the costs or benefits occurring in another year. The discounted costs and benefits in each year can be aggregated to give a **net present value** of future cash flows of the project. The discount rate used will normally be chosen on the basis of prevailing interest rates or on the basis of the minimum desired rate of return for the project. If the net present value is zero or greater, the appraisal shows that the project is capable of yielding the threshold of return.

- ◆ **Internal Rate of Return Method.** The internal rate of return is the discount rate at which the net present value of the project would be zero. This value shows the total rate of return achieved by the project. This rate can be compared to return rates from alternative investment opportunities.

Sensitivity analyses should be done to examine how changes in key parameters such as electricity prices can affect the economic viability of the project. These sensitivity analyses can be carried out before the financing arrangements for the project have been worked out and are useful in providing an initial indication of the project's viability. Further analysis can be conducted to examine the implications for viability of different financing schemes.

# AgSTAR

## Evaluation Form: Dairy Facility

Farm Name: \_\_\_\_\_

Contact Person: \_\_\_\_\_

Phone: \_\_\_\_\_ Date: \_\_\_\_\_

### 1. SITE CLIMATE INFORMATION

State: \_\_\_\_\_

County: \_\_\_\_\_

### 2. FARM TYPE

#### Type of Farm

\_\_\_\_\_ Dairy  
\_\_\_\_\_ Replacement  
\_\_\_\_\_ Heifer

#### Manure Collection Method

\_\_\_\_\_ Flush Barn  
\_\_\_\_\_ Scrape Barn  
\_\_\_\_\_ Flushed Outdoor Lot  
\_\_\_\_\_ Scraped Outdoor Lot  
\_\_\_\_\_ Pasture

### 3. LIVESTOCK POPULATIONS

\_\_\_\_\_ lactating cow

\_\_\_\_\_ dairy heifer

\_\_\_\_\_ dry cow

\_\_\_\_\_ dairy calf

### 4. ANIMAL DISTRIBUTION

Indicate the number of hours the animals spend in each area, per day:

	Lactating Cow	Dry Cow	Dairy Heifer	Dairy Calf
Barn				
Outdoor Lot				
Pasture				
Milking Center				
TOTAL HOURS				

### 4. MANURE MANAGEMENT

#### WATER USE

Building	(1)	(2)		(3)	OR	(4)
	Number of Flush Tanks in All Buildings	Gallons of Recycle Water per Tank	Gallons of Fresh Water per Tank	Flush Frequency		Total Flush (Gallons per day)
Milking Center						
Barn						
Outdoor Lot						
TOTAL						

#### Other systems

Scrape Systems: Frequency of collection \_\_\_\_\_ Per day / Per week / Per month / Per year (circle one)

Solid Separators: Vibrating screen / Screw press / Inclined Screen / Gravity Settling Basing (circle one)

### 5. ENERGY INFORMATION

(Complete this section, or bypass it by attaching copies of past 12 months of energy bills)

#### Overall Energy Costs:

Energy Source	Annual Cost (\$ per year)	Average Unit Cost (\$ per unit)	Unit
Electricity			kWh
Liquid Propane			gallons
Fuel Oil			gallons
Natural Gas			cubic feet

Month	Electric			Liquid Propane		Fuel Oil		Natural Gas	
	Peak kW	kWh	Cost	gals	Cost	gals	Cost	Cubic Feet	Cost
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

**6. HAVE YOU OBTAINED YOUR BILLING HISTORY AND RATE SCHEDULES? (See Appendix G for sample utility letter)**

# AgSTAR

## Evaluation Form: Swine Facility

Farm Name: \_\_\_\_\_

Contact Person: \_\_\_\_\_

Phone: \_\_\_\_\_ Date: \_\_\_\_\_

### 1. SITE CLIMATE INFORMATION

State: \_\_\_\_\_

County: \_\_\_\_\_

### 2. FARM TYPE

#### Type of Farm

\_\_\_\_\_ Farrow-to-Finish  
\_\_\_\_\_ Farrowing  
\_\_\_\_\_ Nursery  
\_\_\_\_\_ Farrow Plus Nursery  
\_\_\_\_\_ Grower-Finish

#### Manure Collection Method

\_\_\_\_\_ Flush Barn  
\_\_\_\_\_ Pull Plug Barn  
\_\_\_\_\_ Pit Recharge  
\_\_\_\_\_ Deep Pit  
\_\_\_\_\_ Hoop Barn  
\_\_\_\_\_ Pasture

### 3. LIVESTOCK POPULATIONS

\_\_\_\_\_ lactating sows

\_\_\_\_\_ nursing pigs

\_\_\_\_\_ feeder pigs

\_\_\_\_\_ gestating sows

\_\_\_\_\_ weaned pigs

\_\_\_\_\_ boars

### 4. MANURE MANAGEMENT

Recycle Flush System

Building	(1)	(2)	(3)	OR	(4)
	Tanks per Building	Gallons of Recycle Water per Tank	Flush Frequency (per day? per week?)		Total Flush (Gallons per day)
1					
2					
3					
TOTAL					

Pull Plug and Pit Recharge Barns

Building	(1)	(2)	OR	(3)
	Gallons of Recycle Water per Pit	Flush Frequency (per day? per week?)		Total Flush (Gallons per day)
1				
2				
3				
TOTAL				

### 5. ENERGY INFORMATION

(Complete this section, or bypass it by attaching copies of past 12 months of energy bills)

#### Overall Energy Costs:

Energy Source	Annual Cost (\$ per year)	Average Unit Cost (\$ per unit)	Unit
Electricity			kWh
Liquid Propane			gallons
Fuel Oil			gallons
Natural Gas			cubic feet

Month	Electric			Liquid Propane		Fuel Oil		Natural Gas	
	Peak kW	kWh	Cost	gals	Cost	gals	Cost	Cubic Feet	Cost
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

**6. HAVE YOU OBTAINED YOUR BILLING HISTORY AND RATE SCHEDULES? (See Appendix G for sample utility letter)**

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# Chapter 5      Securing an Energy Contract

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This chapter provides a guide to the issues involved in negotiating a contract to operate a small biogas fired generator in parallel with a utility. When electrical production is the desired mode of operation, the utility contract is the most important issue affecting the profitability of a project.

While utilities are legally required to work with farm biogas electrical generators, there are no set industry rules or procedures that govern the process for small power producers (<250 kW), as most rules were developed for very large independent power producers (>1 MW). In general, utility rules apply to interconnection requirements, capacity guarantees, and energy payment/purchase rates. In the best of cases, some utilities have developed handbooks of procedures, specifications, options and draft contracts in an effort to provide small power producers with a standard contractual process. In these cases, the process is orderly and straightforward. In other cases, some utilities have dispersed responsibilities across a number of different groups within their organizational structure. These groups may include metering, rates, engineering, agricultural services, and others. In these cases, the process can become confusing, time consuming, and may present impediments to project development. Negotiation is an appropriate method to develop successful small power contracts, given the many approaches utilities may take toward these types of projects. Since contract negotiation is often a complex process, farm owner/operators and developers may want to consult an expert for information and guidance in this area.

Since the first edition of this handbook was written, deregulation has resulted in a major restructuring of electric utilities. Many utilities have sold their generating capacity to independent power producers and now purchase all the electricity delivered to their customers charging a fee for distribution. Theoretically, each customer has or will have choice as to the source of the electricity that they purchase. However, the progress toward total deregulation has varied among states and in some states there is only one choice, especially for residential customers. Conversely, customers in other states may have several options including a supplier that generates "green power" from a renewable resource such as biogas. As a source of green power, farms selling electricity produced using biogas may be able to receive a premium price for the electricity that they

sell to their local utility due to a higher rate structure for electricity generated from a renewable resource.

In Chapter 3, considerations of the types of generation arrangements were discussed. This chapter applies to farm biogas generators operating in parallel with a utility. Operating modes are described, utility contracts are discussed, and the utility contract process is presented.

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## 5-1. Operational Modes

The key issue in developing a biogas recovery system is the value of the energy to the owner. A careful review of utility rates and interconnection requirements are necessary prior to selecting the operating mode. In addition, the owner or developer must realistically estimate the potential to generate electricity and analyze the farm's monthly energy use and history. The analysis may show that the farm will make some surplus electricity or require more than it can produce. Once the potential surplus/shortfall situation is known, the following options may be considered. Not all utilities offer these options under these names.

### 5-1.1 Sale of Electricity to the Utility

In 1978, the Public Utilities Regulatory Policy Act (PURPA) required an electric utility to buy electricity from a power project, that is granted Qualifying Facility (QF) status by the Federal Energy Regulatory Commission (FERC). The electricity would be bought at the utilities' current avoided cost rate. A power project is granted QF status as either a "small power producer" or a "qualifying cogenerator." PURPA prohibits utilities or utility holding companies from having more than 50 percent ownership in QF projects, and it stipulates size and fuel requirements as follows:

**"Small Power Producer.** Small power producers must be no more than 80 MW in size and must use a primary energy source of biomass, waste, renewable resources, or geothermal resources."

Biogas fueled electricity generation qualifies by definition. However, because the avoided cost offered by utilities for purchasing power from QF's,

under PURPA, is much lower today, energy may be more profitably utilized in other operational modes. One option that warrants immediate investigation is the direct sale of energy to a neighboring facility that can use the power.

Currently, the electricity market is undergoing rapid change, including electric utility re-structuring. Re-structuring may provide opportunities as well as challenges that may affect small power production contracts. State actions may impact technology options and the system economics.

The following are typical operating modes for parallel farm digester generators.

### **Buy All - Sell All**

Some utilities offer an agreement where they will continue to sell the farm all electricity requirements and then buy all the generator output. There are very few advantages to this type of arrangement in today's market. In general, utilities offer to pay an avoided cost rate which is 1/4 to 1/3 of what they charge for a retail kilowatt-hour. In rare circumstances a utility will pay an amount close to the value per kilowatt-hour that they charge. However, there also is another version of a Buy All – Sell All agreement that may be available in which the electric utility purchases and uses the biogas produced to generate electricity on the farm. Under this type of agreement, the utility owns the generator set and the interconnection equipment and the electricity generated, which is delivered to the utility's distribution grid. Although all of the electricity used on the farm must be purchased from the utility, the capital and operating costs of the biogas production system are reduced.

### **Surplus Sale**

In a "surplus sale" agreement a farm produces electricity in parallel for use on farm. Excess production is sold at avoided cost and excess consumption is purchased at the retail rate. The surplus sale allows the farm to realize the retail value of a kilowatt-hour by keeping it on farm and using it. In recent years, some utilities have begun charging "standby" rates on these types of projects. The purpose of the standby charge is to pay for the availability of electricity to the farm when the generator is not running.

Typically the standby charge is adequate to recover all utility profits on kilowatt-hours not sold.

### **Net Metering**

In net metering, the generator output is offset on a monthly or yearly basis against the farm consumption with surplus production purchased by the utility or shortages purchased by the farm. The farm is, in effect, trading electricity with the utility (Exhibit 5-1). Many states (AK, CA, CT, DE, HI, ID, IL, IA, LA, MA, ME, MI, MN, NV, NH, NM, ND, NY, OH, OK, PA, RI, TX, VT, WI, WY) allow a net metering arrangement for small generators, but the upper limit for generator size varies from state to state. Net metering may be available from individual utilities in other states, so check with your utility.

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## **5-2. Interconnection Requirements**

An integral part of the contract negotiation involves the interconnection requirements. Each utility has interconnection requirements for protective relays to disconnect the generator automatically if the power line near the farm is accidentally broken or there is a problem with the generator. These relays are necessary for protection of farm and utility personnel. It is recommended that a professional familiar with interconnection equipment negotiate with the utility and supply the appropriate gear. Negotiation is necessary because of the potential cost of the interconnection. Solid state relays and electromechanical relays perform the same generator (disconnect) function. However, electromechanical relays may cost 10 times more. A utility may need high cost relays for very large power producers but lower cost relays are appropriate for smaller farm scale power production.

## 5-3. Whom to Contact

The utility may have a representative who will be able to start you on the path to an energy agreement. The responsible person is usually found in the marketing department. Some utilities have assembled a handbook of procedures, options, and draft contracts. In these cases, the procedure is orderly and straightforward, but will take time. Other utilities have dispersed the responsibilities. In such cases it will take a lot of time to determine what you have to do to interconnect with the utility. The best advice is to ask questions, and if you do not get answers, to ask to talk to someone more senior. In some cases, contacting the state Public Utility Commission (PUC) may be helpful. In all cases, contacting the utility early on in the project development process is essential because of the long lead times often encountered in completing small power contracts. It is suggested that the sample utility letter in Appendix G be used as a tool to initiate this process.

## 5-4. What to Ask For

To begin the contract process the information you need includes but is not limited to:

1. Avoided cost rate schedules
2. Contract Options - for renewable energy projects
  - A. Buy-sell agreement
  - B. Surplus sale agreement
  - C. No sale parallel agreement
  - D. Net sale agreement, if available
  - E. Any other currently available agreements
3. Interconnection requirements
4. Any charges, riders, rate schedules that may be applied to the project (e.g., standby charges)

Examples of some of these documents can be found in Appendix H.

### Exhibit 5-1 The Advantage of Net Metering

This example shows the costs under net metering for a 550 cow, scrape freestall dairy farm with a plug flow digester. The farm generates an average of 70 kW with an average on-farm demand of 50 kW. The example uses a typical utility rate schedule (Service Class 2-D) for the State of New York (Appendix H-5). The generator operates 95 percent of the time.

Delivery rate, \$/kWh	\$0.0265
Supply rate, \$/kWh	\$0.0500
Monthly energy use, kWh	34,200
Monthly excess to grid, kWh	13,680
Net \$ credit at \$.0765/kWh	\$909
Total demand/fixed costs	-\$645
Net monthly credit	\$264
Energy credit at \$.0765/kWh, kWh	3,449
Monthly \$ credit at \$.050/kWh	\$172
Net metering annual credit	\$2,069

After deducting demand charges, the farm's monthly electricity bill includes a 3,449 kWh credit to be carried forward for netting against future month's electricity bills (i.e., whenever farm demand for electricity exceeds the biogas system generation rate). After 12 months, any unused energy credit would be converted to a dollar credit at the utility's avoided energy cost (i.e., supply rate). If on-farm energy demand were fully met each month, the value of the 12-month credit would be \$2,069. Including the value of energy generated for on-farm use, the annual value of the biogas is \$33,465.

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### 5-5. Elements of an Agreement

A long-term contract is usually favored to ensure revenues for projects, and is usually required to obtain financing. However, review short and medium term options to be sure to choose the most beneficial options to the project. Many utilities have a standard offer contract for qualifying facilities such as farm-scale anaerobic digesters.

The entire contract offered by a utility should be carefully reviewed by the project developer and legal counsel to ensure that each of the terms is acceptable. If they are not, a more acceptable, revised version of the contract should be presented to the utility for negotiation. The details of the agreements are crucial to limiting issues that may adversely impact the system in the future.

Primary contract considerations include:

- ◆ **Term.** The contract term should be sufficient to support financing and/or the life of the project. A satisfactory term is usually 15 years or more.
- ◆ **Termination.** Grounds for contract termination should be very limited in order to protect the long-term interests of all parties.
- ◆ **Assignment.** The contract should consider assignment for purposes such as financing. For example, allowing for contract assignment to heirs or to partners may be advisable to avoid ownership arrangement difficulties.
- ◆ **Force Majeure.** Situations that constitute force majeure (e.g., storms, acts of war) should be agreed upon, otherwise this clause could be used to interrupt operations or payment.
- ◆ **Schedule.** There should be some flexibility allowed for meeting milestone dates and extensions (e.g., in penalty provisions such as non-performance). This is necessary in case unforeseen circumstances cause delays.
- ◆ **Price.** The contract price should ensure the long-term viability of the project, which means that accounting for potential cost escalation through the contract term will be very important.

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### 5-6. Why Negotiate and What to Watch Out For

Negotiating is a difficult task and only experience can help. Patience and common sense are virtues. If a contract clause request seems unreasonable, it might be negotiable. However, remember that power contract agreements are binding with the utility, and therefore any changes or agreements need to be in writing.

Utility contracts or standard offers tend to have one or more unique clauses that must be recognized as potentially costly to the project. Some standard offers are developed for certain QF's and then applied to all projects. This is fine if the contract was developed for a small cogenerator, but can be fatal to a small project if the standard clauses were developed for a 2 MW steam turbine project. Some unfavorable clauses from some utility standard offers are summarized below as examples. The owner/developer should be aware that these and other clauses might exist. At a minimum, the financial impact of these clauses on the project, must be fully assessed. Where clauses appear to be unreasonable, they should be renegotiated.

#### 5-6.1 Examples of Contract Elements that May Be Included and Must Be Identified and Renegotiated

These include:

- ◆ **Change in the farm retail rate.** The utility may mandate a new retail rate for a farm with biogas cogeneration. A change in rate affects project financial performance, and must be accounted for in the project's financial analysis.
- ◆ **Standby charges.** Standby charges may be applied to the project by the utility. Standby or "backstand" charges typically are rate schedules or riders that add additional charges to the project. Utilities levy these charges on customers that purchase power on an intermittent or 'as needed' basis, such as those using a farm-scale biogas system. These charges need to be carefully evaluated in terms of their financial im-

pacts on the project, in relation to the expected engine generator performance.

- ◆ **Interconnection requirements.** The Federal Energy Regulatory Commission (FERC) proposed expedited grid-connection procedures for smaller generators, such as digester electricity projects to help standardize the interconnection process and make it less of a burden. Appendix H contains the proposed rules. It is recommended that project developers contact their local utility early in the process to discuss interconnection requirements.
- ◆ **Insurance Requirements.** Liability insurance is a requirement for any project. Most farms have adequate insurance for the operation that will also cover the digester with minimal additional premium. Some utilities have asked farms to add the utility to the policy and to increase the limits of the insurance to levels higher than any farm insurance carrier normally writes.
- ◆ **Monitoring and Reporting.** Some utility companies have clauses requiring such things as hourly reporting of generator output and thermal heat use. They are designed to ensure that natural gas cogenerators meet PURPA thresholds. Such requirements are generally not necessary for a farm digester, and should be renegotiated.
- ◆ **Telemetry.** Some contracts can mandate direct control of the farm generator from the utility power management center, via a leased phone line. This is excessive for small power contracts and is an example of applying large power production specifications to small power producers.
- ◆ **Construction of the Interconnection.** Some utilities prohibit cogenerators from supplying their own equipment. This action can add costs to the project that can affect financial performance. This is another example of applying large power production specifications to small power producers.

The farm has to be careful in rate analysis because “high” demand charges can negate half the value of the electricity produced. “Demand” is usually the highest rate of electricity consumption for 15 minutes during the month. To offset demand charges, a

generator must achieve 99.6% operation. Some utilities offer a “backup” or “standby” charge that is usually a lower fee than a demand charge. FarmWare can be used to evaluate these financial impacts.

### 5-6.2 Benefits to the Utility from Farm Bio-gas Systems

When working with a utility, it is important to remember that these projects can also meet their needs and to emphasize how successful implementation of the project will benefit both parties. For example, there are several non-monetary benefits to a utility from a farm anaerobic digester generator that utilities should consider in project negotiations, including:

1. **Customer Retention.** A digester may allow a farm to continue in business and continue purchasing some of its electricity needs, when a methane recovery system eliminates odor problems with neighbors.
2. **Demand Reduction.** Most utilities try to manage the peak demand by demand side management programs that reward customers for not using electricity during peak demand times. A digester generator reduces farm demand for utility power meeting the management goal.
3. **Voltage Support.** Where farms are near the end of utility transmission laterals, the generator supports the line voltage, keeping it from fluctuating. This saves the utility the cost of providing voltage support or paying for burned out motors.
4. **Deferred Capital Expenditures.** In rural areas, a digester generator (distributed generation) provides a remote generation source. It can delay the need for increasing system capacity and defer expenditures for conductors and substations, by supplying electricity at the point of use.
5. **Greenhouse Gas Reductions.** Several utilities have joined the Climate Leaders Program to reduce emissions of greenhouse gases. Methane recovery from animal wastes and combustion reduces its atmospheric effects. The recovery of

one pound of methane is the same as reducing carbon dioxide emissions by 21 pounds. By encouraging biogas production and its use to generate electricity, the utility objectives to reduce greenhouse gas emissions are advanced without capital expenditures.

- 6. Renewable Portfolio Standards.** A Renewable Portfolio Standard (RPS) requires that a minimum amount of renewable energy is included in the portfolio of electricity resources serving a particular area. Utility purchases of electricity from biogas projects may help meet these RPS requirements.

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### **5-7. Transmission (Wheeling) Arrangements**

Another option for producing revenue from biogas generated electricity is the direct sale to a third party using the local utility transmission lines. This strategy may be possible if the local utility is required to enter into a long-term contract to deliver or “wheel” electricity from other generators at a reasonable price. Also, farms with more than one site may be able to wheel surplus electricity via the local utility lines to their other locations. Wheeling could produce more revenue than the sale of surplus electricity to the local electric utility or may be an option if an acceptable long-term purchase agreement cannot be negotiated with the local utility. Before considering wheeling, contact the Public Utility Commission to determine if electric utilities in the state are required to wheel electricity generated by small power producers.

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## Chapter 6

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# Selecting a Consultant/Developer/ Partner

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This chapter provides a guide to selecting a consultant, turn-key developer, or partner.

The selection of a consultant or developer is a critical decision. The farm owner often relies on the consultant or developer to manage the process of transforming a feasible idea into a functioning facility. Some owners have the expertise, resources, and desire to lead the development effort on their own, but even in this case, choosing the right consultant can greatly improve the likelihood of project success. This chapter provides guidance to owners who are attempting to determine: (1) the role that they might take in the development process; (2) the right consultant to get the project developed, financed, and built; and (3) if an investment partner would be advisable.

From the owner's perspective, there are three general ways to structure the development of a biogas project:

1. **Owner-Builder.** Farm owner hires a consultant, plans and manages the design-construction effort, and maintains ownership control of the project. This approach maximizes economic returns to the owner, but also places most of the project risks on the owner (e.g., construction, equipment performance, financial performance).
2. **Purchase Turn-Key Project.** Owner selects a qualified development company to provide the owner with a "turn-key" digester plant, which is built by the developer but owned by the farm owner.

The "turn-key" digester plant option requires expertise in developing the following areas: (1) Digester; (2) Gas Handling; (3) Engines; (4) Utility Interconnection; and (5) Utility Rates.

3. **Team With a Partner:** Owner teams with an equipment vendor, engineering/procurement/construction (EPC) firm or investor to develop the project and to share the risks and financial returns.

With these structures in mind, a farm owner can determine his or her desired role in the project development process by considering two key questions:

- ◆ Should the owner self-develop, buy a turn-key project, or find a partner?
- ◆ If a partner is desired, what kind of partner best complements the owner and the project?

The owner can answer the first question by conducting a frank examination of his or her own expertise, objectives, and resources. The second question is more complicated because it entails an assessment of the owner's specific needs and a search for the right partner to complement those needs.

Appendix I provides a list of suppliers, vendors, and EPC firms.

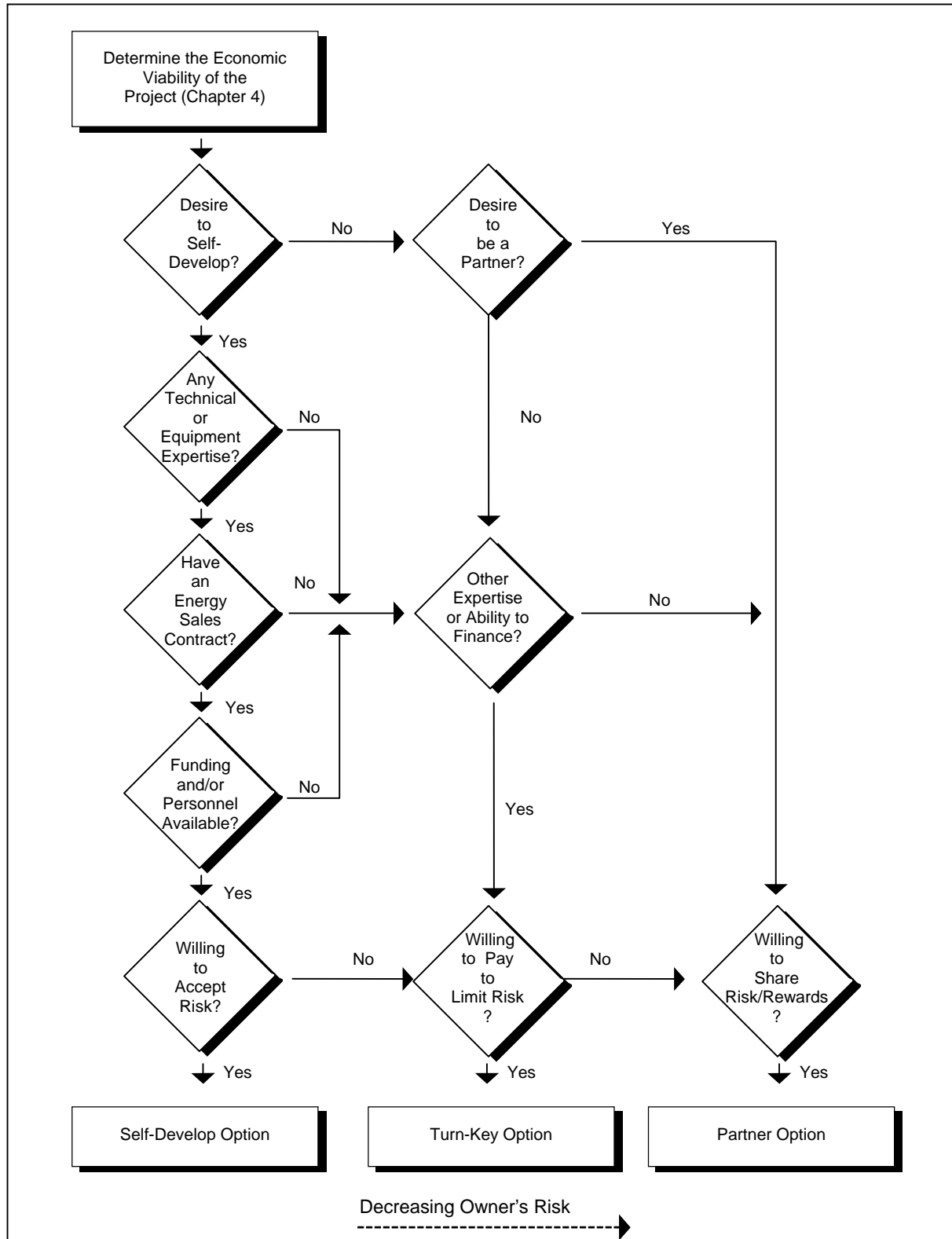
Exhibit 6-1 illustrates the process of determining the best development approach. As it indicates, in cases where the owner wants to be involved in the project development process, a number of issues must be considered. These issues are discussed in the following sections.

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## 6-1. The Do-It-Yourself/Turn-key Decision

Before deciding whether to develop the project internally, the owner must understand the tasks involved in a project, which are outlined in Exhibit 6-2.

Next, an assessment of the owner's objectives, expertise, and resources determines whether or not the owner should undertake project development independently or try to find a turn-key developer.

**Exhibit 6-1** The Developer Selection Process

An owner with the following attributes is a good candidate for developing a project with a consultant alone:

- ◆ strong desire to develop a successful, profitable energy project;
- ◆ willingness to accept project risks (e.g., construction, equipment, permitting, financial performance);
- ◆ expertise with technical projects or energy equipment;
- ◆ high confidence level regarding biogas quantity and quality (i.e., modeling or testing have been completed);
- ◆ sufficient internal electricity demand or possession of a power sales agreement with a local electric utility or an electric consumer; and

- ◆ funds and personnel available to commit to the construction process.

Similarly, a strong desire for new business opportunities and/or visibility is beneficial. The type of owner that fits this profile is one who owns, operates, and repairs farm equipment.

If the owner is uncertain about several of the attributes listed above, particularly the desire to build, the willingness to take significant risks, and/or their level of technical expertise, then he or she might instead choose a turn-key builder.

The following are several good reasons to develop the project with a turn-key builder:

- ◆ limited desire to lead the development effort;

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### Exhibit 6-2 Project Development Tasks

- Determine Biogas Supply If the owner has not already completed this step, then the first development step will be to determine the biogas supply using calculations, computer modeling, and/or testing.
- Scope Out the Project Project scoping includes preliminary tasks such as selecting a site, developing a site plan, determining structural and equipment needs, estimating costs and biogas production potential, and contacting the local utility.
- Conduct Feasibility Analysis Feasibility analysis includes detailed technical and economic calculations to demonstrate the technical feasibility of the project and estimate project revenues and costs.
- Select Equipment Based on the results of the feasibility analysis, primary equipment is selected and vendors are contacted to assess price, performance, schedule, and guarantees.
- Create a Financial Pro Forma A financial pro forma is usually created to model the cash flows of a project and to predict financial performance.
- Negotiate the Utility Agreement The terms of the agreement must be negotiated with the purchasing electric utility.
- Obtain Environmental and Site Permits All required environmental permits and site permits/licenses must be acquired.
- Gain Regulatory Approval Some power projects must obtain approval from state regulators or certification by the Federal Energy Regulatory Commission (FERC).
- Secure Financing All the tasks above are needed to determine economic viability to allow financiers to loan money for the project.
- Contract with Engineering, Construction, Equipment Supply Firms Firms must be selected and contracts and terms negotiated.

- ◆ limited technical resources and/or experience;
- ◆ need to share or avoid specific project risks;
- ◆ difficulty financing the project alone;
- ◆ inability to dedicate personnel or time to the development effort;
- ◆ project development outside the scope of organization.

The questions in Exhibit 6-1 illustrate other critical considerations in making the owner-builder/turn-key decision. Most owners choose self build with consultant or turn-key options.

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## 6-2. Selecting a Consulting Firm

Once the decision to self build with a consultant has been made, the owner should review the capabilities of individual consulting firms that meet the owner's general needs. When selecting a consultant, there are several qualities and capabilities that owners should look for, including:

- ◆ previous biogas project experience;
- ◆ a successful project track record; and
- ◆ in-house resources (e.g., engineering, finance, operation) including experience with environmental permitting and community issues.

Information about individual firm qualifications can be gained from reports, brochures, and project descriptions, as well as from discussions with references, other owners, and engineers. Potential warning signs include: lawsuits, disputes with owners, lack of operating projects and failed projects (although a few failed efforts and/or underperforming projects can normally be found in the portfolio of any consultant). Published information can be obtained by researching trade literature, through legal information services, and through computer research services.

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## 6-3. Selecting a Turn-Key Developer

Selecting a turn-key developer to manage the development process is a good way for the owner to shed development responsibility and risks, and get the project built at a guaranteed cost. In addition, the developer typically provides the owner with the strongest development skills and experience. Other reasons for selecting a turn-key developer include:

- ◆ the developer's skills and experience may be invaluable in bringing a successful project on-line and keeping it operational; and
- ◆ some developers have access to financing.

In return for accepting project risks, most turn-key projects cost more than self built systems. The turn-key option is a good approach if the owner does not want the risk and responsibility of construction. In a turn-key approach, the developer assumes development responsibility and construction risk, builds the facility, and then receives payment when the facility is complete and performing up to specifications. The turn-key approach enables each entity to contribute what it does best: the developer accepts development, construction, and performance risk; and the owner accepts financial performance risk.

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## 6-4. Selecting a Partner

A partner reduces risks to the owner by bearing or sharing the responsibilities of project development, although the amount of risk reduction provided depends on the type of partner chosen.

Selecting a partner who is not a developer is a good choice if two key conditions exist:

1. The owner wants to keep management control of the project and has sufficient in-house expertise and resources to do so; and,
2. The partner can fulfill a specific role or provide equipment for the project.

In this case, the owner must have a clear desire to manage the development process and should have sufficient technical experience, personnel, and funds to support the effort. The owner should also have a relatively high confidence level regarding biogas production capability, as well as a willingness to accept a significant share of the project's risks (e.g., financial, environmental permitting, community acceptance).

There are three basic types of firms that may enter into partnership agreements with owners: equipment vendors, EPC firms, and investors. Each of these firms has different strengths and will assume different types of project risk. The key characteristics of these types of firms are summarized below.

- ◆ **Equipment Vendors.** Some equipment vendors such as engine manufacturers become partners in energy projects, including biogas projects, as a way to support the sale of equipment and services to potential customers. Equipment vendors may assist in financing the project, and may be willing to accept the equipment performance risk over a specified length of time for the equipment that they provide. However, equipment vendors typically do not take on responsibilities beyond their equipment services, and they generally want to recover their interest in a project as quickly as possible after the project has been built.
- ◆ **EPC Firms.** Similarly, some of the biogas EPC firms may become partners in biogas power projects with the objective of selling services and gaining a return on equity and/or time invested. However, this type of partner tends primarily to pursue large projects (i.e., >1 MW) where the EPC's strength as a man-

ager of large, complex projects is more valuable.

- ◆ **Investment Firm.** Finally, an individual or investment company might become a partner in the biogas project if it has significant use for any available tax credits, or if the project has an attractive rate of return on investment.

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## 6-5. Preparing a Contract

Once the firm has been selected, the terms of the agreement should be formalized in a contract. The contract should accomplish several objectives, including allocating risk among project participants. Some of the key elements of a contract are listed in Exhibit 6-3.

As Exhibit 6-3 indicates, contracting with a developer or partner in a biogas energy project can be a complex issue. Each contract will be different depending on the specific nature of the project and the objectives and limitations of the participants. Because of this complexity, the owner may wish to hire a qualified attorney to prepare and review the contract.

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### **Exhibit 6-3** Elements of a Consultant Contract

The contract between the owner and the consultant, developer, or partner should describe in detail the responsibilities of each party, any payments to be made, and any warranties and/or guarantees. Some specific items that should be addressed include:

- Ownership shares
- Allocation of responsibility
- Decision-making rights
- Commitments of equity, financing, equipment, and/or services
- Payments, fees, royalties
- Hierarchy of project cash distributions
- Allocation of tax credits
- Allocation of specific risks (e.g., equipment performance, gas flow)
- Penalties, damages, bonuses
- Schedules and milestones
- Termination rights clause
- Buy-out price
- Remedies/arbitration procedures

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# Chapter 7      Obtaining Project Financing

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This chapter provides a guide to obtaining project financing and provides some insights into what lenders and investors look for. It is assumed that the farm owner has experience borrowing money from banks or other agricultural lenders, and has first discussed financing a biogas system with their own lender.

This chapter discusses alternative financing methods, some advantages and disadvantages of each method, and some potential sources for financing.

The following general categories of project financing avenues may be available to biogas projects:

- ◆ waste management cost sharing or renewable energy loan/grant programs,
- ◆ debt financing,
- ◆ equity financing,
- ◆ third-party financing, and
- ◆ project financing.

Federal cost sharing or state energy low interest loans or partial grants may be available for anaerobic digester projects. Debt financing is probably the most common method used for funding agricultural biogas projects. Equipment leasing, one method of third-party financing is used occasionally. Equity financing other than by the owner is rarely used, while project financing has never been used, but may be available to very large projects in the future.

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### **7-1. Financing: What Lenders/Investors Look For**

Lenders and investors will decide to finance a biogas project based upon its expected financial performance and risks. Financial performance is usually evaluated using a pro forma model of project cash flows as discussed in Chapter 4. FarmWare, when properly used, can provide financial performance information for securing financing.

A lender or investor usually evaluates the financial strength of a potential project using the two following measures:

- ◆ **Debt Coverage Ratio:** The main measure of a project's financial strength is the farm's ability to adequately meet debt payments. Debt-coverage is the ratio of operating income to debt service requirements, usually calculated on an annual basis.
- ◆ **Owner's Rate of Return (ROR) on Equity:** If a digester system is essential to continuation of farm operations, a break-even project is very satisfactory to the owner. However, banks or other lenders currently prefer to see a ROR between 12% and 18% for most types of projects. Outside investors will typically expect a ROR of 15% to 20% or more.

Exhibit 7-1 summarizes the project risk categories, viewed from the lender's perspective. The most important actions to control risks are to obtain contracts securing project construction costs and revenues. Potential investors and lenders will look to see how the farm owner or project developer has addressed risks through contracts, permitting actions, project structure, or financial strategies.

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### **7-2. Financing Approaches**

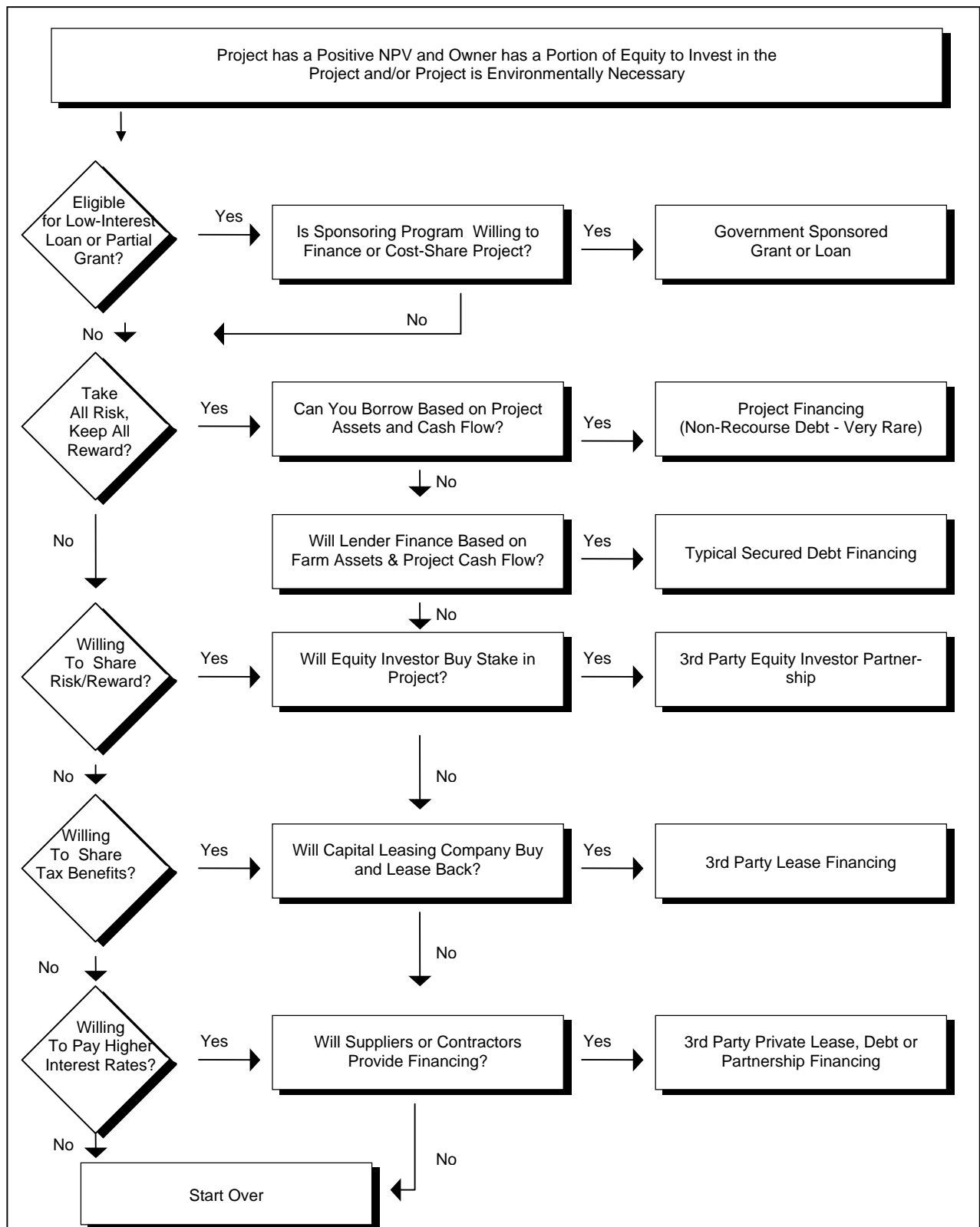
This section briefly discusses funding resources for digester projects and the means of securing financing from the five sources listed above. The use of third-party financing is briefly discussed. The advantages and disadvantages of each approach are also discussed. Exhibit 7-2 is a flow chart summarizing the decision process for selecting the appropriate source of financing.

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**Exhibit 7-1 Addressing Biogas Project Risks**

<b>Risk Category</b>	<b>Risk Mitigation Measure</b>
Biogas Production Potential	<ul style="list-style-type: none"><li>• Use FarmWare to model gas production over time</li><li>• Hire expert to report on gas production potential</li><li>• Provide for back-up fuel if necessary</li></ul>
Construction	<ul style="list-style-type: none"><li>• Execute fixed-price turn-key contracts</li><li>• Include monetary penalties for missing schedule</li><li>• Establish project acceptance standards, warranties</li><li>• Be sure the project conforms to NRCS standards</li></ul>
Equipment performance	<ul style="list-style-type: none"><li>• Select proven designer, developer, and technology</li><li>• Design for biogas Btu content</li><li>• Get performance guarantees, warranties from vendors</li><li>• Select and train qualified operators on farm</li></ul>
Environmental permitting	<ul style="list-style-type: none"><li>• Obtain permits prior to financing (waste management, building)</li></ul>
Community acceptance	<ul style="list-style-type: none"><li>• Obtain zoning approvals</li><li>• Demonstrate community support</li></ul>
Utility agreement	<ul style="list-style-type: none"><li>• Have signed contract with local utility</li><li>• Make sure all aspects are covered</li><li>• Get sufficient term to match debt repayment schedule</li><li>• Confirm interconnection point, access, requirements</li><li>• Make sure on-line date is achievable</li><li>• Include force majeure provisions in agreement</li></ul>
Financial performance	<ul style="list-style-type: none"><li>• Create financial pro forma</li><li>• Calculate cash flows, debt coverages</li><li>• Commit equity to the project</li><li>• Ensure positive NPV</li><li>• Maintain working capital, reserve accounts</li><li>• Budget for major equipment overhauls</li></ul>

**Exhibit 7-2.** Financing Strategy Decision Process



### 7-2.1 Looking for Cost Share Financing or Low Interest Loans or Grants

There are few outright grant programs remaining for anaerobic digestion system funding. It may be possible to receive a portion of the project funding from public agency sources. The Environmental Quality Incentives Program (EQIP), administered by USDA's Natural Resources Conservation Service (NRCS), promotes agricultural production and environmental quality as compatible goals. EQIP was reauthorized and the funding amount significantly expanded under the Farm Security and Rural Investment Act of 2002, which requires that 60 percent of EQIP funds be spent on animal operations. Anaerobic digesters may qualify for cost share funding under NRCS programs. The owner should check with the local or state NRCS offices to see if a digester project may qualify.

Another potential source of funding is a state energy program. At the time of publication, the status of renewable energy low-interest loan or grant programs is in flux. AgSTAR has identified approximately 30 states that offer financial assistance in the form of low-interest loans, property tax exemptions, and grants. To learn more about these state programs and other federal funding opportunities, review the AgSTAR publication, *Funding On-Farm Biogas Recovery Systems*, EPA-430-F-04-002, December 2003. Also Appendix B provides a list of NRCS and Department of Energy contacts who should be able to help the owner contact the correct person in his state.

The advantage to receiving funding is the reduced project cost. The disadvantages are the time and effort it takes to apply for and receive funding monies.

### 7-2.2 Debt Financing

Most agricultural biogas projects built in the last 15 years used debt financing, where the owner borrowed from a bank or agricultural lender. The biggest advantage of debt financing is the ability to use other people's money without giving up ownership control. The biggest disadvantage is the difficulty in obtaining funding for the project.

Debt financing usually provides the option of either a fixed rate loan or a floating rate loan. Floating rate loans are usually tied to an accepted interest rate index like U.S. treasury bills.

#### Lender's Requirements

In deciding whether or not to loan money, lenders examine the expected financial performance of a project and other underlying factors of project success. These factors include contracts, project participants, equity stake, permits, technology, and sometimes, market factors. A good borrower should have most, if not all, of the following:

- ◆ Signed interconnection agreement with local electric utility company
- ◆ Fixed-price agreement for construction
- ◆ Equity commitment
- ◆ Environmental permits
- ◆ Any local permits/approval

However, most lenders look at the assets of an owner or developer, rather than the cash flow of a digester project. If a farm has good credit, adequate assets, and the ability to repay borrowed money, lenders will generally provide debt financing for up to 80 percent of a facility's installed cost.

Lenders generally expect the owner to put up an equity commitment of about 20 percent of installed cost using his/her own money and agree to an 8 to 15 year repayment schedule. An equity commitment demonstrates the owner's financial stake in success, as well as implying that owner will provide additional funding if problems arise. The expected debt-equity ratio is usually a function of project risk.

Lenders may also place additional requirements on project developers or owners. Requirements include maintaining a certain minimum debt coverage ratio and making regular contributions to an equipment maintenance account, which will be used to fund major equipment overhauls when necessary.

#### Securing Project Financing

Agricultural biogas projects have historically experienced difficulty in obtaining debt financing from

commercial lenders because of their relatively small size and the perceived risk associated with the technology. The best opportunities for agricultural biogas projects to secure debt financing are with banks, smaller capital companies, where the owner currently borrows money, or at one of the energy investment funds that commonly finance smaller projects.

There are public sources that may provide debt financing for agricultural biogas projects. The US Department of Agriculture's Farm Service Administration (FSA) is a common source of debt financing for agricultural projects. Additionally, the Small Business Administration can guarantee up to \$1,000,000 for Pollution Control Loans to eligible businesses. Pollution Control Loans are intended to provide loan guarantees to eligible small businesses for the financing of the planning, design, or installation of a pollution control facility. The SBA suggests that farmers first exhaust FSA loan possibilities.

It may be worth contacting local and regional commercial banks. Some of these banks have a history of providing debt financing for small energy projects, and may be willing to provide project financing to a "bundle" of two or more farm biogas projects. However, transaction costs for arranging debt financing are relatively high, owing to the lender's due diligence (i.e., financial and risk investigation) requirements. It is often said that the transaction costs are the same for a 100-kW project as they are for a 10-MW or greater project. For this reason, most large commercial banks and investment houses hesitate to lend to farm scale projects with capital requirements less than about \$20 million.

### **7-2.3 Equity Financing**

Investor equity financing is a rarely used method of financing agricultural biogas projects. Project investors typically provide equity or subordinated debt. Equity is invested capital that creates ownership in the project, like a down payment on a home mortgage. Equity is more expensive than debt, because the equity investor accepts more risk than the debt lender. This is because debt lenders usually require that they be paid from project earnings before they are distributed to equity investors. Thus, the cost of financing with equity is usually significantly higher than financing with debt. Subordinated debt is re-

paid after any senior debt lenders are paid and before equity investors are paid. Subordinated debt is sometimes viewed as an equity-equivalent by senior lenders, especially if provided by a credit-worthy equipment vendor or industrial company partner.

There are two methods for equity finance: self and investor. Regardless of method, the following basic principles apply.

In order to use equity financing, an investor must be willing to take an ownership position in the potential biogas project. In return for this share of project ownership, the investor is willing to fund all or part of the project costs. Project, as well as some equipment vendors, fuel developers, or nearby farms could be potential equity investors.

The primary advantage of this method is its availability to most projects; the primary disadvantage is its high cost.

#### **Investor's Requirements**

The equity investor will conduct a thorough due diligence analysis to assess the likely ROR associated with the project. This analysis is similar in scope to banks' analyses, but is often accomplished in much less time because of the entrepreneurial nature of equity investors as compared to institutional lenders. The equity investor's due diligence analysis typically includes a review of contracts, project participants, equity commitments, permitting status, technology and market factors.

The key requirement for most pure equity investors is sufficient ROR on their investment. The due diligence analysis, combined with the cost and operating data for the project, enables the investor to calculate the project's financial performance (e.g., cash flows, ROR) and determine its investment offer based on anticipated returns. An equity investor may be willing to finance up to 100% of the project's installed cost, often with the expectation that additional equity or debt investors will be located at a later time.

Some types of partners who provide equity or subordinated debt may have unique requirements. Potential partners such as equipment vendors generally expect to realize some benefits other than just cash

flow. The desired benefits may include equipment sales, service contracts, tax benefits, and economical and reliable energy supplies. For example, an engine vendor may provide equity or subordinated debt up to the value of the engine equipment, with the expectation of selling out its interest after the project is built. A nearby farm company might want to gain access to inexpensive fuel or derived energy. The requirements imposed by each of these potential investors are sure to include an analysis of the technical and financial merit of the project, and a consideration of the unique objectives of each investor.

### **Securing Equity Financing**

To fully explore the possibilities for equity or subordinated debt financing, farm owners should ask potential developers if this is a service they can provide. The second most common source of equity financing is an investment bank that specializes in the placement of equity or debt. Additionally, the equipment vendors, and companies that are involved in the project may be willing to provide financing for the project, at least through the construction phase. The ability to provide financing could be an important consideration when selecting a builder, equipment vendor, or other partners.

### **7-2.4 Third-Party Financing**

Should a farm owner or project developer be unable to raise the required capital using equity or debt or be unwilling to accept project risks, one last form of financing might be considered. With each of the following methods, the project sponsor gives up some of the project's economic benefits in exchange for a third-party becoming responsible for raising funds, project implementation, system operation, or a combination of these activities. Some of the disadvantages of third-party financing include accounting and liability complexities, as well as the possible loss of tax benefits by the farm owner.

#### **Lease Financing**

Lease financing encompasses several strategies in which a farm owner leases all or part of the project's assets from the asset owner(s). Typically, lease arrangements provide the advantage of transferring tax benefits such as accelerated depreciation or energy tax credits to an entity that can best use them. Lease

arrangements commonly provide the lessee with the option, at pre-determined intervals, to purchase the assets or extend the lease. Several large equipment vendors have subsidiaries that lease equipment, as do some financing companies. There are several variations on the lease concept including:

- ◆ **Leveraged Lease.** In a leveraged lease, the equipment user leases the equipment from the owner, who finances the equipment purchase with extended debt and/or equity.
- ◆ **Sales-Leaseback.** In a sales-leaseback, the equipment user buys the equipment, then sells it back to a corporation, which then leases it back to the user under contract.
- ◆ **Energy Savings Performance Contracting (ESPC).** ESPC is another contracting agreement that might enable a large project to be implemented without any up-front costs. The ESPC entity, such as a venture capitalist or green investor, actually owns the system and incurs all costs associated with its design, installation, or maintenance in exchange for a share of any cost savings. The ESPC entity recovers its investment and ultimately earns a profit. It is earned by charging the farm for supplied energy at a rate below what energy from a conventional utility would cost. The end-user must usually must commit to take a specified quantity of energy or to pay a minimum service charge. This "take or pay" structure is necessary to secure the ESPC.

### **7-2.5 Project Financing**

"Project finance" is a method for obtaining commercial debt financing for the construction of a facility. Lenders look at the credit-worthiness of the facility to ensure debt repayment rather than at the assets of the developer/sponsor. Farm biogas projects have historically experienced difficulty securing project financing because of their relatively small size and the perceived risks associated with the technology. However, project financing may be available to large projects in the future. In most project finance cases, lenders will provide project debt for up to about 80% of the facility's installed cost and accept a debt repayment schedule over 8 to 15 years. Pro-

ject finance transactions are costly and often an onerous process of satisfying lenders' criteria.

The biggest advantage of project finance is the ability to use others' funds for financing, without giving up ownership control. The biggest disadvantage is the difficulty of obtaining project finance for farm biogas projects.

The best opportunities for farm biogas projects to secure project financing are with project finance groups at smaller investment capital companies and banks. Opportunities also exist at one of several energy investment funds that commonly finance smaller projects. Some of these lenders have experience with landfill gas projects and may also be attuned to the unique needs of smaller projects.

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### **7-3. Capital Cost Effects of Financing Alternatives**

Each financing method produces a different weighted cost of capital. This affects the amount of money that is spent to pay for a farm biogas power project and the energy revenue or savings needed to cover project costs.

The weighted cost of capital is dependent on the share of project funds financed with debt and equity, and on the cost of that debt or equity (i.e., interest rate on debt, ROR on equity). The more common private equity structure is the 50% debt case, and the more common project finance structure is the 80% debt case. For example, in a project finance scenario with a debt/equity ratio of 80/20, an interest rate on debt of 9%, and an expected ROR on equity of 15%, the weighted cost of capital is 10.2%. Decreasing the amount of debt to 70% means that more of the project funds must be financed with equity, which carries a higher interest rate than debt, so the weighted cost of capital becomes 10.8%. Increasing the weighted cost of capital means that project revenues must be increased to pay the added financing charges. In contrast a lower weighted cost of capital lessens the amount of money spent on financing charges, which makes the project more competitive.

Interest rates are an important determinant of project cost if the owner decides to borrow funds to finance the project. For example, raising interest rates by 1% would cause an increase of about 2% to 3% in the cost of generating electricity from a biogas project. Interest rates are determined by the prevailing rate indicators at a particular time, as well as by the project and lender's risk profiles.

Among the five main financing methods presented above, cost sharing by public agencies coupled with debt financing usually produces the lowest financing costs over time, while private equity financing produces the highest. Generally, the five financing methods are ranked from lowest cost to highest cost as follows:

1. Cost share plus debt financing
2. Debt financing
3. Lease financing
4. Project financing
5. Private equity financing.

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# Chapter 8      Permitting and Other Regulatory Issues

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This chapter provides a guide to permitting and other regulatory issues. In general, there have been few permits required for farm biogas systems. Today, however, permitting activities for all farm manure management systems are increasing.

Obtaining the required environmental, siting, and other permits is an essential step in the project development process. Permit conditions may affect project design, and neither construction nor operation should begin until all permits are in place. The process of permitting a digester gas-to-energy project may take anywhere from 4 to 9 months to complete, depending on the project's location and recovery technology. For example, a project sited in a location that requires no zoning variances will probably take much less time to permit than a project subject to zoning hearings.

It should be noted that states are generally granted the authority to implement, monitor, and enforce the federal regulations by establishing their own permit programs. As a result, some state permit program requirements are more stringent than those outlined in the federal regulations and there is a large state-to-state variance in agencies and standards. For this reason, owner/operators and project developers should determine state and local requirements before seeking project permits.

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## 8-1. The Permitting Process

There are four general steps (outlined in the flowchart in Exhibit 8-1) in the permitting process:

- ◆ **Step 1. Hold preliminary meetings with key regulatory agencies.** Meet with regulators to identify permits that may be required and any other issues that need to be addressed. These meetings also give the developer the opportunity to educate regulators about the project, since biogas technologies may be unfamiliar to regulators.
- ◆ **Step 2. Develop the permitting and design plan.** Determine the requirements and assess agency concerns early on, so permit applications

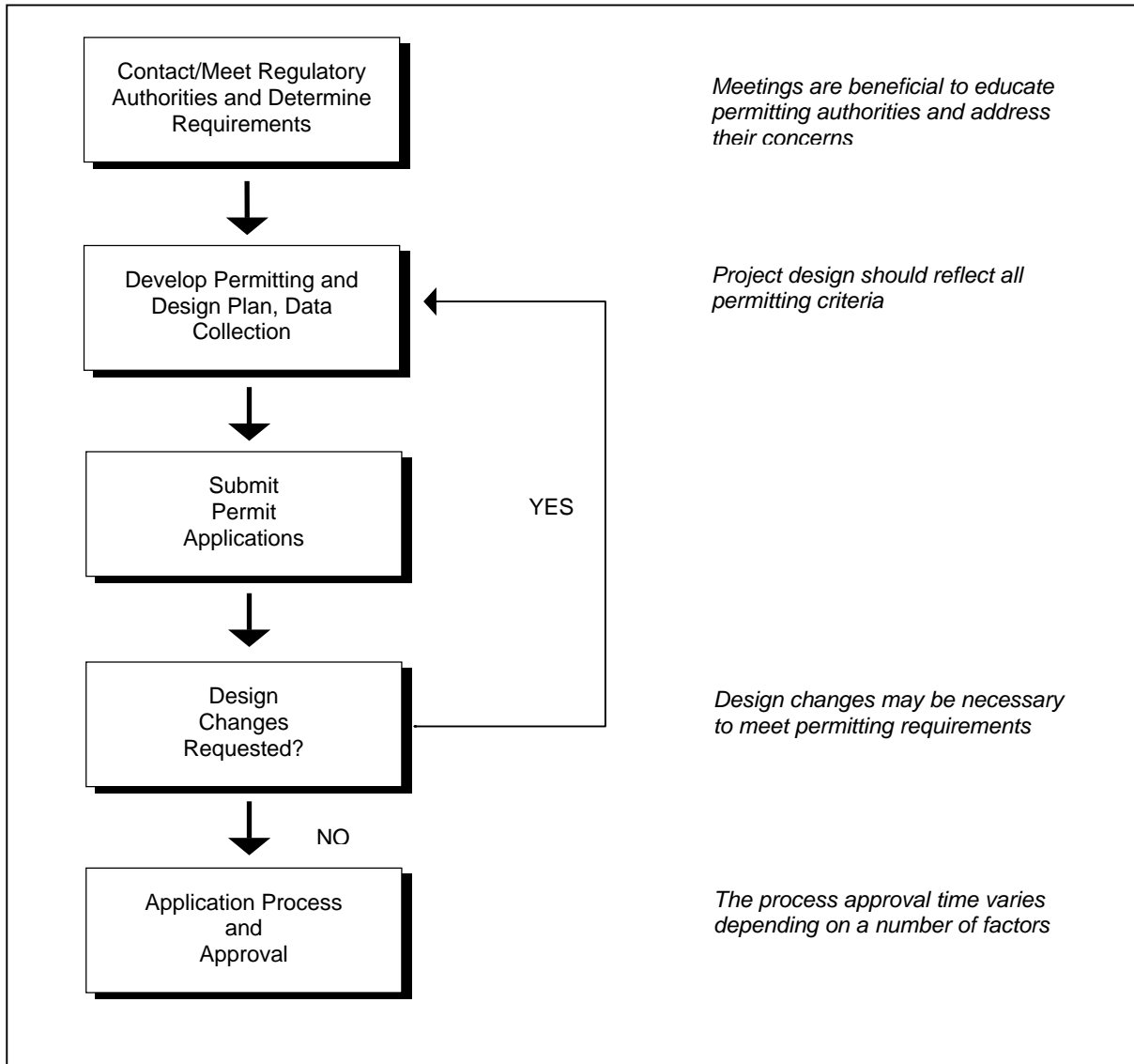
can be designed to address those concerns and delays will be minimized.

- ◆ **Step 3. Submit timely permit applications to regulators.** Submit complete applications as early as possible to minimize delays.
- ◆ **Step 4. Negotiate design changes with regulators in order to meet requirements.** Permitting processes sometimes provide opportunities to negotiate with regulators. If negotiation is allowed, it may take into account technical as well as economic considerations.

As these steps indicate, the success of the permitting process relies upon a coordinated effort between the developer of the project and various agencies who must review project plans and analyze their impacts. Project developers might have to deal with separate agencies with overlapping jurisdictions, underscoring the importance of coordinating efforts to minimize difficulties and delays.

In some cases, permitting authorities may be unfamiliar with the characteristics and unique properties of biogas. Where appropriate, the owner/operator or project developer should approach the permitting process as an opportunity to educate the permitting authorities, and should provide useful, targeted information very early in the process. Local and state NRCS representatives may be of assistance regarding whom to contact.

Emphasizing the pollution and odor control aspects of biogas energy recovery projects can be an effective approach in seeking permits and may make the permitting process much easier.

**Exhibit 8-1** The Permitting Process

Local approval of a project is crucial to its success. This approval refers not only to the granting of permits by local agencies, but also to community acceptance of the project. Strong local sentiment against a project can make permitting difficult, if not impossible.

## 8-2. Zoning and Permitting

Project siting and operation are governed by local jurisdictions (in addition to federal regulations). Therefore, it is imperative to work with regulatory bodies throughout all stages of project development to minimize permitting delays, which cost both time and money. This is especially important since the pollution prevention benefits of projects may not initially be considered.

### 8-2.1 Zoning/Land Use

The first local issue to be addressed is the compatibility of the project with community land use specifications. Projects on existing farms should have few problems. Most communities have a zoning and land use plan that identifies where different types of development are allowed (e.g., residential, commercial, industrial). The local zoning board determines whether or not land use criteria are met by a new farm project, and can usually grant variances if conditions warrant.

### 8-2.2 Permitting Issues

In addition to land use specifications, local agencies have jurisdiction over a number of other parameters that may or may not be applicable to the project or location, such as the following:

- ◆ **Confined Animal Facility Operation Permits (CAFO).** Depending on the size of the animal confinement operation, a state agency regulated confined animal facility operation (CAFO) permit may be in force. The permit was developed under the National Pollution Discharge Elimination System (NPDES). Generally, any alteration in methodologies employed to manage manure require review and approval by that agency. Discussion of project benefits (odor, pathogen, weedseed, nutrient mineralization) may aid the regulators during preliminary conversation and subsequent authorization.
- ◆ **Recycling.** Projects with financial viability dependent on sale of recycled materials likely are subject to review of the state/regional agency governing recycling programs. Some degree of marketing research and product purchase commitment may be required. This is particularly true of projects generating revenues through the receipt of “tipping” fees to receive wastes for disposal and processing. Regulators do not want materials received for an income-generating fee to accumulate and not be subsequently sold.
- ◆ **Noise.** Most local zoning ordinances stipulate the allowable decibel levels for noise sources. These levels vary, depending on the zoning classification at the source site (e.g., a site lo-

cated near residential areas will have a lower decibel requirement than one located in an isolated area). Even enclosed facilities may be required to meet these requirements; therefore, it is important to keep them in mind when designing project facilities.

- ◆ **Wastewater.** All farms remain under zero discharge rules for digester effluent. The CAFO permits control facilities and operations.
- ◆ **Water.** Water requirements depend on the type and size of the project. If current facilities cannot meet the needs of the project, then new facilities (e.g., pipeline, pumping capacity, wells) may need to be constructed. Groundwater permits could be required if new wells are needed to supply the project's water needs.
- ◆ **Solid Waste Disposal.** The only solid wastes generated by a biogas project are likely packaging materials, cleaning solvents, and equipment fluids. While there may only be a small amount of solid waste generated, it must be properly disposed.
- ◆ **Stormwater Management.** State environmental agencies regulate stormwater management, and may require a permit for discharges during construction and operation. Good facility design that maintains the predevelopment runoff characteristics of the site allows the project to easily meet permitting requirements.

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## 8-3. Community Acceptance

As any project developer will attest, community support is extremely important to the success of a project, especially since some communities require public participation in project zoning/siting cases. Many farms are encountering local opposition such as the “not in my backyard (NIMBY)” syndrome, or perceptions of project impacts (e.g., odor, groundwater pollution). Therefore, it is important to educate the public and to develop a working relationship with the neighboring community in order to dispel any fears or doubts about the expected impact

of the project. Project details should always be presented in a very forthcoming and factual manner.

Biogas projects bring many benefits to the neighboring community (e.g., improved air quality, reduction of odor and pollution potential). These benefits should be emphasized during the permitting process. AgSTAR materials may be used to fulfill some of these needs.

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### **8-4. Regulations Governing Air Emissions from Energy Recovery Systems**

New Source Review (NSR) is a preconstruction review program under the Clean Air Act that applies to new and modified major sources. In almost all cases, farm scale biogas systems will be too small to trigger NSR permitting. NSR most likely will apply only to biogas-fueled boilers, engine-generator sets, and flares for very large projects and projects on farms near large urban areas. However, each state has a permitting program for new or modified minor sources. The emission thresholds for requiring a minor source permit or registration vary by state. Therefore, you should check with your local air permitting authority about permit requirements early in the planning process.

Links to state and local air pollution control agencies can be found at [www.cleanairworld.org](http://www.cleanairworld.org).

Regulations have been promulgated under the Clean Air Act governing airborne emissions from new and existing sources. These regulations require new or modified major sources to undergo the NSR process before they can commence construction. The addition of a biogas recovery system at an existing farm would be an example of a modified source. The purpose of NSR is to ensure that new and modified major sources meet the applicable air quality standards and that emissions are controlled using state-of-the-art technology.

The permit requirements will vary depending on local air quality. All areas of the country are classified by their attainment status with National Ambi-

ent Air Quality Standards (NAAQS) for six pollutants - sulfur dioxide, particulate matter, nitrogen dioxide, carbon dioxide, lead, and ozone. Areas that meet the NAAQS for a particular air pollutant are classified as in "attainment" for that pollutant. Areas that do not meet the NAAQS are classified as in "nonattainment" for that pollutant.

Permitting requirements are more stringent for non-attainment areas. Under NSR, sources in attainment areas undergo Prevention of Significant Deterioration (PSD) permitting while those in nonattainment areas undergo nonattainment area NSR permitting. Nonattainment area permitting requires more stringent emission controls and imposes other requirements. Because a location can be classified as attainment for some pollutants and nonattainment for others, a source may be permitted under both PSD and nonattainment area NSR. For example, a biogas combustion engine may be reviewed under PSD for carbon monoxide and nonattainment NSR for ozone.

In summary, small projects that are typical of most farm scale biogas systems may find the air permitting process to be quite straightforward. Very large projects (i.e., >500 kW), particularly those in urban nonattainment areas, may require NSR. The process of obtaining a NSR permit can be extensive and can require lead times of 6 to 9 months to obtain a permit. Construction of a project cannot begin until the permit is issued. Given the complexity of the air permitting regulations, an owner/operator may wish to consult an expert familiar with the NSR process in a particular area.

#### **8-4.1 NO<sub>x</sub> Emissions from Energy Conversion**

Combustion of biogas -- in an engine, turbine, or boiler -- generates nitrogen oxides (NO<sub>x</sub>). For biogas combustion sources, NO<sub>x</sub> is likely to be the emission of greatest concern to state air pollution regulators. Nitrogen oxides contribute to the formation of atmospheric ozone and fine particulate matter. Obtaining a permit may require selection of a combustion device with low NO<sub>x</sub> emissions.

#### **Reciprocating Internal Combustion Engines**

There are two basic types of reciprocating engines: naturally aspirated and fuel injected lean-burn:

- ◆ **Naturally Aspirated** engines draw combustion air and biogas through a carburetor in stoichiometric proportions, much the same way that an automobile equipped with a carburetor would draw its air/fuel mixture. Just enough air is drawn into the combustion chamber to ignite the air/biogas mix. In addition, residence time in the combustion chamber is relatively long. Therefore, this type of engine emits relatively high levels of  $\text{NO}_x$
- ◆ **Fuel injected lean-burn** engines inject biogas into the combustion chamber along with air that is in excess of the stoichiometric mix. This type of engine provides both greater engine power output and fewer  $\text{NO}_x$  emissions than a comparable naturally aspirated engine. In recent years, manufacturers have developed engines with very low  $\text{NO}_x$  emissions.

When internal combustion engines are used in conventional natural gas applications, catalysts can be used to reduce  $\text{NO}_x$  emissions. To date, catalysts have not been required in any farm scale applications because the impurities found in biogas quickly limit the ability of the catalyst to control  $\text{NO}_x$  emissions.

### **Turbines and Boilers**

With modern designs, gas-fired boilers and turbines emit levels of  $\text{NO}_x$  that are lower than fuel injected lean burn internal combustion engines. For typical farm scale systems, additional controls should not be required to obtain a permit.

### **8-4.2 $\text{SO}_x$ Emissions from Energy Conversion**

Combustion of biogas also can generate sulfur oxides ( $\text{SO}_x$ ). Sulfur oxides are generated when biogas containing hydrogen sulfide and other reduced sulfur compounds are combusted. Sulfur oxides contribute to the formation of fine particulate matter.

In some areas, obtaining a permit may require installation of a scrubbing technique to remove hydrogen sulfide and other reduced sulfur compounds before biogas combustion. It is likely that only biogas produced from large swine operations would contain enough sulfur compounds to warrant the consideration of scrubbing.

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# Appendix A    Operating U.S. Farm-Scale Digesters

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This section provides information on farm-scale digester systems currently operating at commercial livestock farms in the U.S. Of the 40 operating digester systems, nine are at swine farms, 29 are at dairy farms, one is at a caged layer farm, and one is at a duck farm. Three of these systems are centralized digester operations for dairy farms that receive manure from surrounding dairy farms. Table A-1 provides information about each of these digester systems. The table is organized by animal type and state location.

In the past two years, the number of operating farm-scale digesters has increased by nearly 30 percent. In addition, seven additional systems are currently under construction or in start-up (Table A-2). AgSTAR estimates that in October 2002, at least 40 additional systems were in various stages of planning and should come on line during the next several years.

In 35 of the 40 operational systems, the captured biogas is used to generate electrical power and heat. The systems combined produce the equivalent of approximately 4 MW of energy output per year. The remaining five systems flare the captured gas for odor control. Each year, the 40 operating digesters prevent the emission of nearly 124,000 metric tons of methane, on a carbon dioxide equivalent basis,<sup>1</sup> from entering the atmosphere.

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<sup>1</sup>Greenhouse gas emissions are most commonly expressed as metric tons of carbon dioxide equivalents (MTCO<sub>2</sub>E/year). This measure is used to compare the emissions of different greenhouse gases based on their potential to trap heat in the atmosphere. Methane has 21 times the global warming potential of CO<sub>2</sub>. A metric ton is 1.1 tons.

## Appendix A

## Operating U.S. Farm-Scale Digesters

**Table A-1. Operating U.S. Digesters, October 2002**

Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
<b>Dairy Farms</b>								
CA	Mesophilic plug flow, flexible top	1982	Dairy; 400 milkers	Scrape	\$200,000	Electricity and hot water	40	1,186
CA	Mesophilic plug flow, flexible top	2002	Dairy; 650 milkers	Solids separator; scrape	\$386,000	Electricity and hot water	100	2,965
CA	Unheated partially covered lagoon	1998	Dairy; 200 to 300 cows	Flush	\$225,000	Flare	0	800
CA	Thermophilic-mesophilic complete mix tanks	2001	Dairy; 5,000	Vacuum scrape	Not available	Electricity and hot water	200	119
CA	Mesophilic plug flow, fixed top	2002	Dairy; 7,000 milkers, 3,000 other	Vacuum scrape	\$1,800,000	Electricity and hot water	500	296
CA	Unheated partially covered lagoon	2000	Dairy; 200 milkers, 50 dry	Flush and scrape	Not available	Electricity and hot water	25	741
CT	Mesophilic complete mix	1997	Dairy; 600 milkers	Scrape	\$450,000	Electricity	55	1,631
CT	Mesophilic plug flow, flexible cover	1997	Dairy; 200 milkers	Scrape	\$149,000	Hot water and flare	0	1,387

## Appendix A

## Operating U.S. Farm-Scale Digesters

Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
FL	Unheated fixed film	2000	Dairy; 500 cows	Hydraulic flush	\$150,000	Hot water and flare	0	3,467
IA	Mesophilic plug flow, fixed top	2002	Dairy; 480 cows	Scrape	\$348,000	Electricity and heat	80	2,372
IA	Mesophilic plug flow, fixed top	2002	Dairy, 800 cows	Scrape	\$450,000	Electricity and hot water	100	2,965
IA	Mesophilic plug flow, fixed top	2002	Dairy; 170 (100 milkers, 20 dry)	Scrape	\$200,000	Hot water	0	1,179
IL	Mesophilic plug flow, flexible top		Dairy; 1,400 lactating	Scrape	\$1,200,000	Electricity	360	10,673
IL	Mesophilic plug flow, flexible top		Dairy; 2,000 lactating	Scrape	\$875,000	Electricity	246	7,293
MD	Mesophilic slurry loop tank	1994	Dairy; 120 lactating, 70 heifers	Scrape	\$500,000	Flare	0	1,317
MI	Plug flow	1981	Dairy; 730 milkers	Scrape	\$150,000	Electricity	0	5,061
MN	Mesophilic plug flow, flexible top	1999	Dairy; 850 milkers	Scrape	\$355,000	Electricity and hot water	130	3,854
NY	Mesophilic plug flow, flexible top	1998	Dairy; 500 to 550	Scrape	\$295,700	Electricity and hot water	44	3,640
NY	Mesophilic complete mix tank	1985	Dairy; 295 milkers	Scrape	\$500,000	Electricity and hot water	25	2,045

## Appendix A

## Operating U.S. Farm-Scale Digesters

Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
NY	Mesophilic complete mix, flexible top	2001	Dairy; 560 milkers, 40 dry	Scrape and gravity flow	\$350,000	Electricity and hot water	130	3,854
NY	Mesophilic plug flow, flexible top	2001	Dairy; 850 milkers, 100 dry	Continuous scrape	\$400,000	Hot water	0	1,779
NY	Mesophilic, fixed film tank	2001	Dairy; 100 milkers	Gutter flush with liquid solids separation	Not available	Hot water	0	693
PA	Mesophilic slurry loop, fixed top	1983	Dairy; 250 milkers	Scrape	\$80,000	Electricity and hot water	45	1,334
PA	Mesophilic slurry loop, fixed top	1979, 1981, 1984	Dairy; 2,300 milkers	Scrape	\$225,000 each	Electricity and hot water	350	10,376
VT	Mesophilic plug flow, flexible top	1982	Dairy; 340 milkers	Scrape	\$300,000	Electricity and hot water (steam)	28	2,357
WI	Mesophilic plug flow, flexible top	2002	Dairy; 900 cows	Scrape	\$425,000	Electricity and hot water	125	3,706
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 600 milkers	Scrape	\$550,000	Digester and dairy heat, electricity, and hot water	135	4,002

## Appendix A

## Operating U.S. Farm-Scale Digesters

Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 750 cows	Recycle flush	\$487,500	Electricity, heat, and hot water	160	4,743
WI	Mesophilic two-stage mixed, fixed top	2002	Dairy; 2,800 milkers	Scrape	\$1,400,000	Digester heat, dairy heat, solids drying, electricity, hot water, and flare	425	12,600
<b>Swine Farms</b>								
CA	Unheated covered lagoon	1982	Swine; 300 sows farrow-to-finish	Flush	\$220,000	Electricity and hot air	25	741
CO	Mesophilic complete mix, flexible top	1999	Swine; 5,000 sow farrow-to-wean and 1,200 growing pigs	Pull plug	\$368,000	Electricity	50	1,482
IA	Unheated bank-to-bank covered lagoon	1998	Swine; 3,000 nursery pigs	Pull plug	\$15,000	Flare	0	1,738
IA	Mesophilic complete mix, flexible top	1996	Swine; 5,000 sows farrow-to-wean	Pull plug	\$500,000	Electricity	50	1,482

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## Appendix A

## Operating U.S. Farm-Scale Digesters

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Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
IL	Mesophilic bank-to-bank covered lagoon	1998	Swine; 8,300 finishing hogs	Pull plug	\$140,000	Hot water and flare	0	2,380
MS	Unheated bank-to-bank covered lagoon	1998	Swine; 145 pigs	Recycle flush	\$27,000	Flare	0	84
NC	Unheated bank-to-bank covered lagoon	1997	Swine; 4,000 sows farrow-to-wean	Pull plug and gravity flow	\$290,000	Electricity and hot water	41	2,317
PA	Mesophilic plug flow, flexible top	1985	Swine; 4,000	Scrape	\$225,000	Electricity and hot water; flare	130	3,854
PA	Mesophilic complete mix	1985	Swine; 1,000 sows farrow-to-finish	Scrape	\$325,000	Electricity and hot water	33	1,666

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## Appendix A

## Operating U.S. Farm-Scale Digesters

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Location	Digester Type	Year Operational	Animal Type and Population	Manure Handling Method	Approximate Total Installed Cost	Biogas End-Use	Operational Output (kilowatt)	Methane Reduction (MTCO <sub>2</sub> E/year)
Other Animal Operations								
PA	Mesophilic plug flow, slurry loop, fixed top	1983	Chicken; 350,000 caged layers	Scrape	\$125,000	Electricity and hot water	150	4,447
WI	Mesophilic complete mix, fixed top	1988	Ducks; 300,000	Scrape	\$500,000	Digester heat and electricity	180	5,336

Reprinted from U.S. EPA, "Current Status of Farm-Scale Digesters," *AgSTAR Digest*, Winter 2003, available online at [www.epa.gov/agstar/library/digest.htm](http://www.epa.gov/agstar/library/digest.htm)

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## Appendix A      Operating U.S. Farm-Scale Digesters

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**Table A-2. U.S. Digesters Under Construction and in Start-Up, October 2002**

Location	Digester Type	Animal Type and Population	Manure Handling Method	Estimated Total Installed Cost	Biogas End-Use
IN	Mesophilic two-stage mixed, fixed top	Dairy; 3,500 cows	Scrape	\$1,750,000	Digester heat, solids drying, dairy heat, electricity, hot water, and flare
MN	Mesophilic plug flow, flexible top	Dairy; 3,000 milkers	Scrape	Not available	Electricity
NY	Mesophilic plug flow, fixed top	Dairy; 1,100 cows	Scrape	\$650,000	Electricity and hot water
NY	Mesophilic plug flow, fixed top	Dairy; 1,000 milkers, 200 dry	Scrape	\$900,000	Electricity, hot air, and hot water
OR	Mesophilic complete mix, fixed top	Dairy; 325 milkers	Scrape	Not available	Electricity
OR	Mesophilic plug flow, flexible top	Dairy; 4,000 cows	Scrape	Not available	Electricity
WI	Thermophilic complete mix, fixed top	Dairy; 1,425 milkers	Scrape	Not available	Electricity

Reprinted from U.S. EPA, “Current Status of Farm-Scale Digesters,” *AgSTAR Digest*, Winter 2003, available online at [www.epa.gov/agstar/library/digest.htm](http://www.epa.gov/agstar/library/digest.htm)

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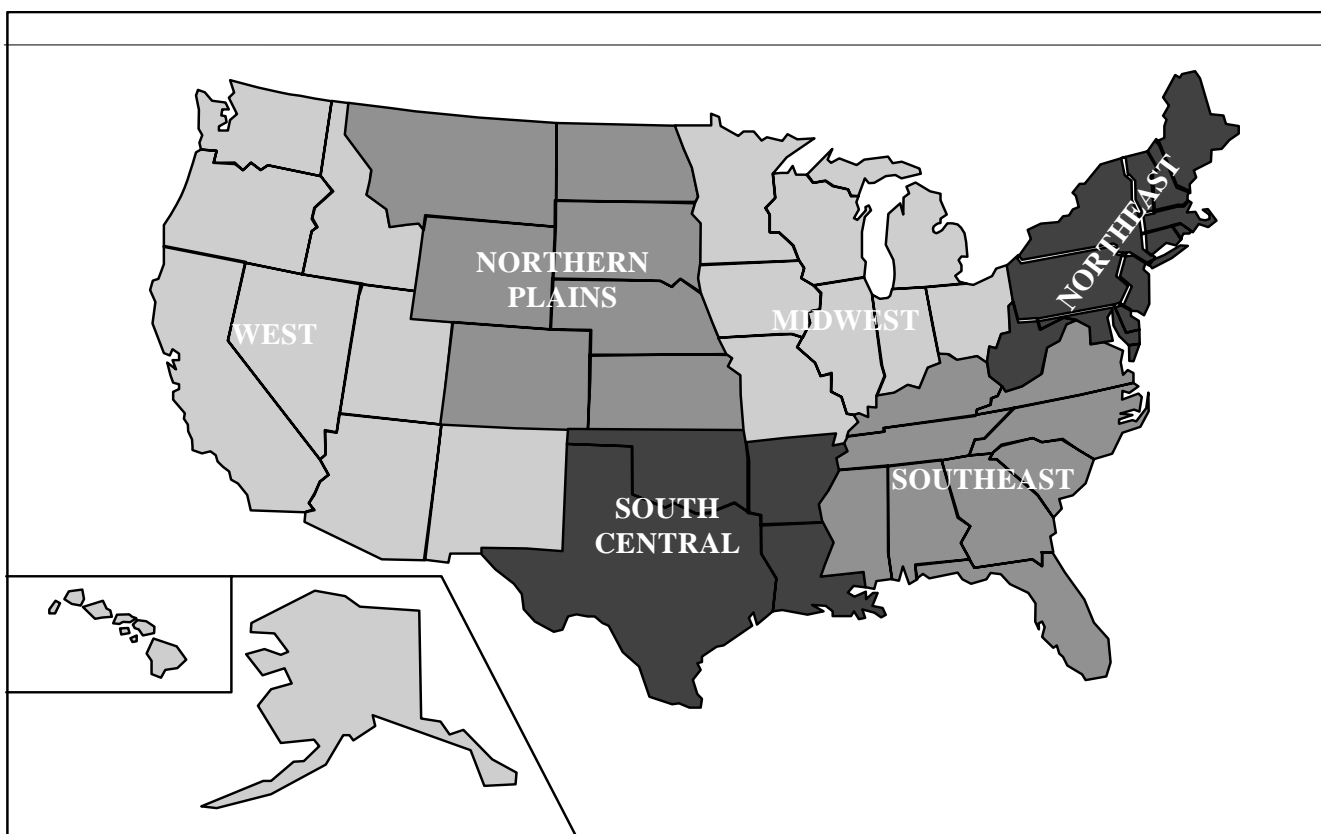
# Appendix B    National Resource Conservation Service and U.S. Department of Energy Regional Contacts

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## Appendix B-1

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## National Resource Conservation Service (NRCS) Contacts

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#### Washington D.C.

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## Appendix B-1

## National Resource Conservation Service (NRCS) Contacts

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## SOUTH CENTRAL

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States served: Connecticut, Delaware, Maine,  
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and Vermont

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**SOUTHEAST**

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Norcross, GA 30092  
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States served: Alabama, Arkansas, Florida,  
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**GREAT LAKES**

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Chicago, IL 60601  
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Fax: 312/407-0038

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**WESTERN**

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Golden, CO 80401  
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Fax: 303/275-4830

States served: Arizona, California, Colorado,  
Kansas, Nebraska, Nevada, New Mexico, North  
Dakota, Oklahoma, South Dakota, Texas, Utah,  
and Wyoming.

---

**PACIFIC NORTHWEST**

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Tel: 206/553-2079  
Fax: 206/553-2200

States served: Alaska, Hawaii, Idaho, Oregon,  
Montana, and Washington.

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### CHAPTER 1.0:      INTRODUCTION TO FARMWARE

This User's Guide provides step-by-step instructions and guidance on how to use AgSTAR FarmWare 3.0.

#### 1.1      Background

AgSTAR FarmWare 3.0 is a computerized decision support program that assesses whether or not a methane production, capture, and utilization system can be integrated into your farm's existing or planned manure management system. FarmWare estimates how much the system will cost and the financial benefits that may be gained by producing energy for on-farm use or sale or both.

If you were a FarmWare 2.0 user, you will notice some changes in FarmWare 3.0. FarmWare 3.0 contains the same options and general information; however, the user interface has been updated and the Interview portion of the application was removed. Additionally, FarmWare 3.0 presents environmental benefits associated with the use of biogas recovery waste management. Finally, FarmWare 3.0 contains an option to simultaneously model the performance of a waste management system with and without anaerobic digestion and biogas recovery.

#### 1.2      Purpose and Scope

This User's Guide provides step-by-step instructions and guidance about how to use FarmWare 3.0 and contains:

- Instructions for first-time users;
- An introduction to navigating through FarmWare; and
- Information for each of FarmWare's primary components.

#### 1.3      Limitations

The FarmWare assessment is only the first step in evaluating the technical and financial feasibility of biogas production for use as a source of energy at a farm. This assessment should be considered preliminary and only be used as input to determining whether to proceed with a more rigorous assessment. It is imperative that a qualified engineer conducts a detailed feasibility assessment prior to commencing facility design or construction activities.

It is important to note also what types of farms are best suited for a biogas recovery system. Livestock facilities that collect manure on a daily basis as a liquid (total solid content < 5%), slurry (total solid content of 5% to 10%), or semi-solid (total solid content of 10% to 20%) are the best candidates for a biogas recovery system.

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### 1.4 Document Conventions

This user's guide will use the following conventions:

- **Bold** = software tab name in the various screens;
- Underline = software labels on the various screens; and
- *Italic* = software buttons on the various screens.

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### CHAPTER 2.0: GETTING STARTED

The following sections describe what you need to know to begin using FarmWare 3.0.

#### 2.1      System Requirements

FarmWare requires the following:

- Hardware Requirements
  - IBM compatible computer with a Pentium processor,
  - 128 megabytes of RAM (256 megabytes of RAM recommended),
  - Hard drive with at least 50 megabytes of space available, and
  - Mouse to operate the menus and screens.
- Software Requirements
  - Microsoft Windows XP or 2000.
- Other
  - Screen Resolution (recommended) 800 x 600 or greater, and
  - Printer, to print FarmWare reports.

#### 2.2      Installing FarmWare

To install FarmWare on your computer, follow the instructions below:

- Copy the installation file from the FarmWare CD or from the EPA AgStar webpage: <http://www.epa.gov/agstar/resources/handbook.html> onto your hard drive;
- Double select the installation file named "setup.exe"; and
- Follow the onscreen instructions during the installation process.

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### CHAPTER 3.0: STARTING AND RUNNING FARMWARE 3.0

FarmWare 3.0 appears as a folder in your programs menu. To run FarmWare 3.0, double-click the FarmWare name.

#### 3.1 Welcome Screen

Upon opening FarmWare 3.0, the Welcome Screen appears which provides the user with the option to *Create a new assessment* or *Open an existing assessment*.



**Figure 3-1. Welcome Screen**

If this is your first time using FarmWare or would like to start a new assessment select *Create a new assessment*. If you have a previously saved assessment that you would like to access then select *Open an existing assessment*.

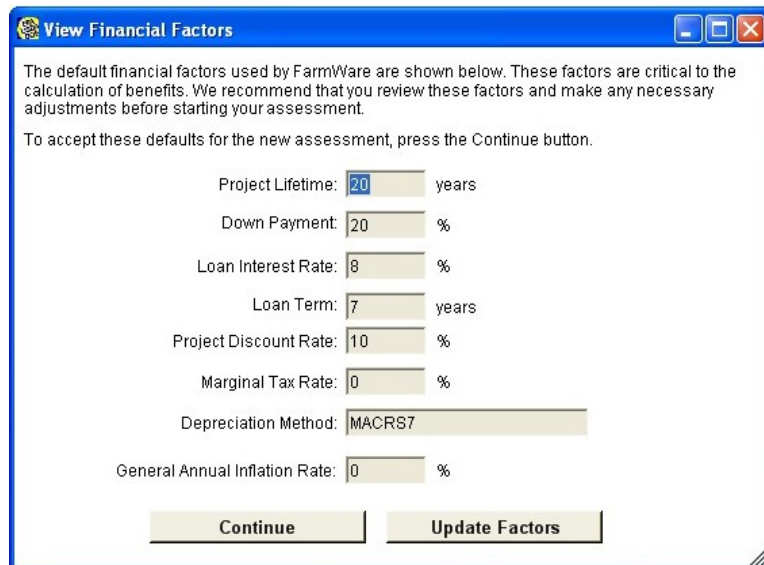
You may choose to bypass this Welcome Screen in the future by selecting the box "Don't show this window again." In that case, the next time FarmWare opens, the user will be immediately directed to the Assessment page from which the user may select to *Create a New Assessment* or *Open an Existing Assessment*.

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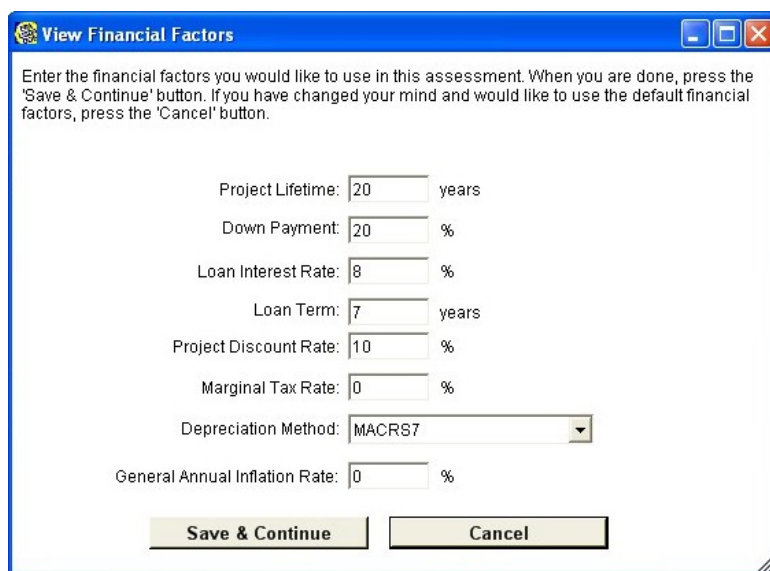
### 3.2 Financial Factors Screen

Upon clicking on *Create a new assessment*, the user is taken to the Financial Factors screen.



**Figure 3-2. Financial Factors Screen**

The financial factors are critical to the economic calculations in FarmWare. Therefore, it is recommended that the user review the factors before starting the assessment. The Financial Factors screen has default values already input into the assessment. The user can accept the default values by selecting *Continue*, or select *Update Factors*. The user should then select *Save & Continue* or *Cancel*. (The user may update the factors at anytime from the **Assessment** tab, which is discussed in Chapter 4.0 of this user's guide.)



**Figure 3-3. Financial Factors Update Screen**

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### 3.3      Navigating the FarmWare Tabs

FarmWare 3.0 has a total of nine tabs: **Assessment, General Information, Farm Setup, Livestock, Conventional Process Train, Biogas Process Train, Energy Consumption, Costs & Revenues, and Report.** When the program is initialized, FarmWare requires that the user complete the tabs in order. Once the user has moved onto a new tab, the user must complete all the required fields in the tab before moving forward to the next tab or going back to a previous tab.

The user may scroll through the tabs but clicking on the "<<Previous" and "Next >>" buttons or on the tabs at the top of the screen. The current tab is highlighted in dark blue and named in the bar across the top of the tabs.

### 3.4      Information Required to Complete a Fare Ware Assessment

Before beginning a new FarmWare session, the user should ensure that he has many pieces of information that are required in each tab. Table 3-1 presents a list of these data elements. In addition, Chapter 4.0 of the AgSTAR Manual presents Evaluation Forms for dairy and swine facilities. These are also useful to the data collection process.

**Table 3-1. Information Required to Complete the Assessment**

Topic/Screen	Data Element	
General Information	Farm Type Farm Name	County State
Farm Setup	Confinement areas Process Water use per day	Liquid-slurry waste management system description Solid waste management description
Livestock	Ages and numbers of animals on site	Hours spend in each housing area defined in Farm Setup
Energy Consumption	Type of available electric utility contract available	Historical energy use and costs
Costs and Revenues	Other revenue sources	

In addition to this user-entered data, FarmWare also provides default values for other data needed in the analysis, including those data shown in Table 3-2. The user may change these values within the assessment.

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**Table 3-2. Default Information Used to Complete the Assessment**

Topic/Screen	Data Element	
Financial Factors	Project Lifetime Percent Down Payment Loan Interest Rate Length of the Loan	Project Discount Rate Marginal Tax Rate Depreciation Method General Annual Inflation Rate
Daily Livestock Excretion Rates	Manure Total Solids Volatile Solids	Nitrogen Phosphorous Average animal weight
Process Water Use	Per confinement area, per animal	

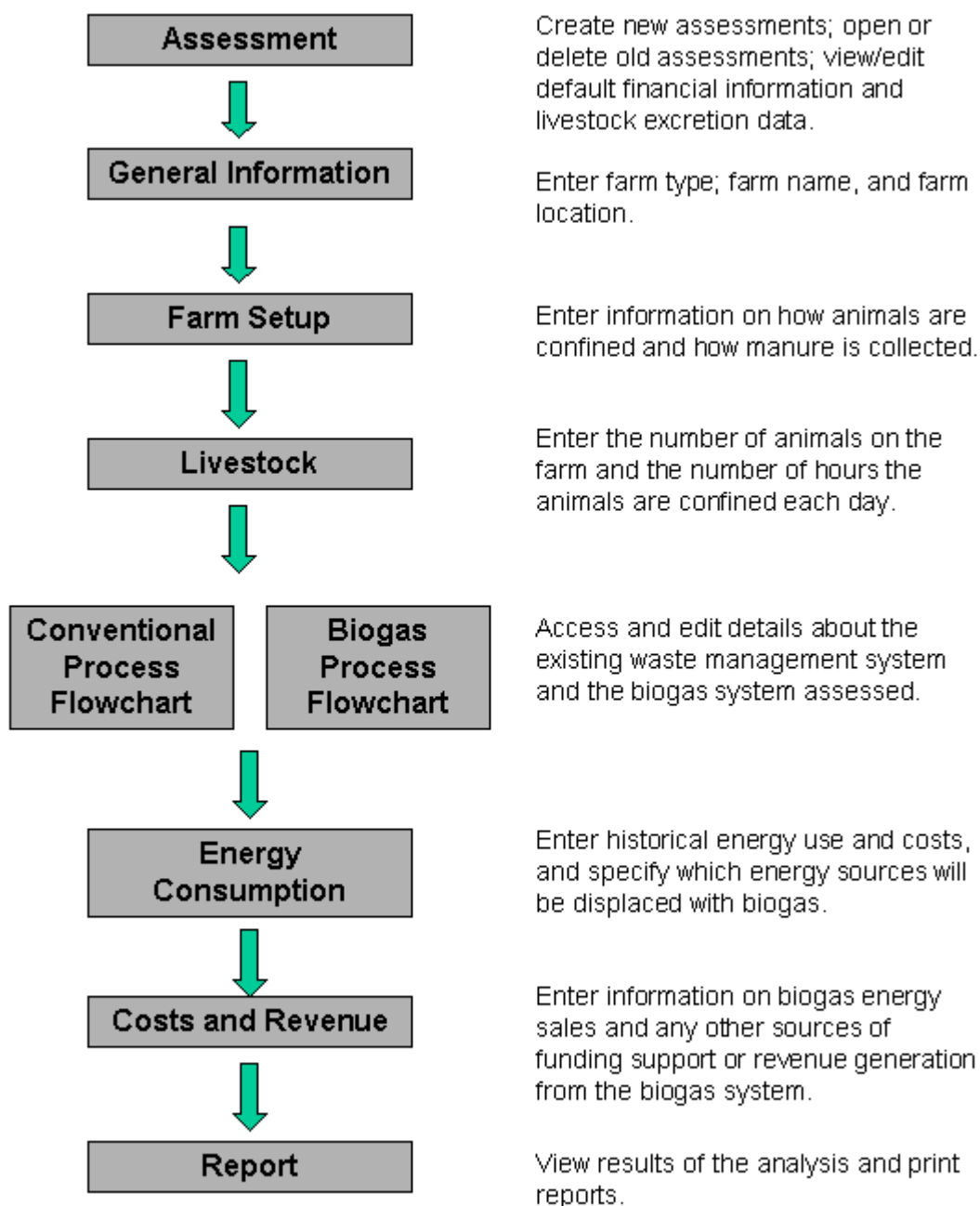
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#### Functions of the FarmWare Tabs



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### CHAPTER 4.0: ASSESSMENT TAB

There are five options to choose from the **Assessment** tab: *Create New Assessment*, *Open Assessment*, *Delete Assessment*, *View/Edit Financial Factors*, and *View/Edit Manure Excretion Rates*. From this tab, the user can create a new assessment, open or delete existing assessments, and after an assessment is selected, the user may view and edit financial factors and manure excretion rates.

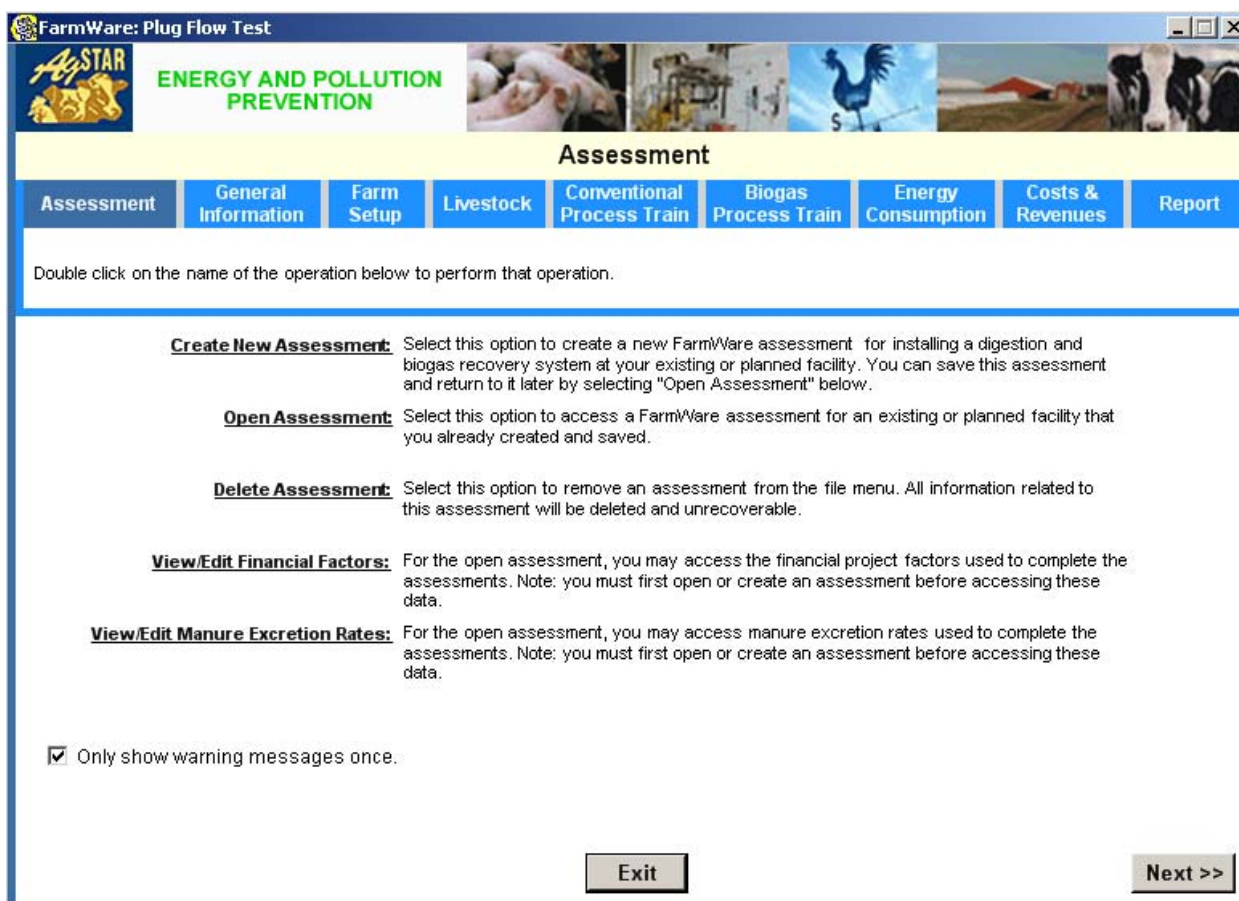


Figure 4-1. Assessment Tab

#### 4.1 Create a New Assessment

The user can select *Create a New Assessment* to begin a new FarmWare assessment describing an existing or planned operation. By clicking on this button, the current assessment immediately closes and a new one is created. The user is then brought to the **General Information** tab. Note: to get back to the **Assessment** tab again, the user will need to complete the required information in the **General Information** tab or select *Cancel* to return to the **Assessment** tab.

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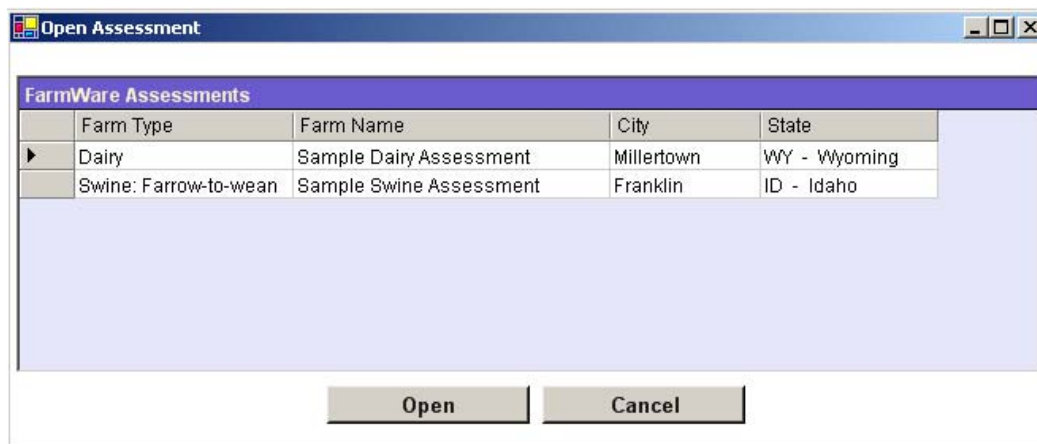
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#### 4.2      Open Assessment

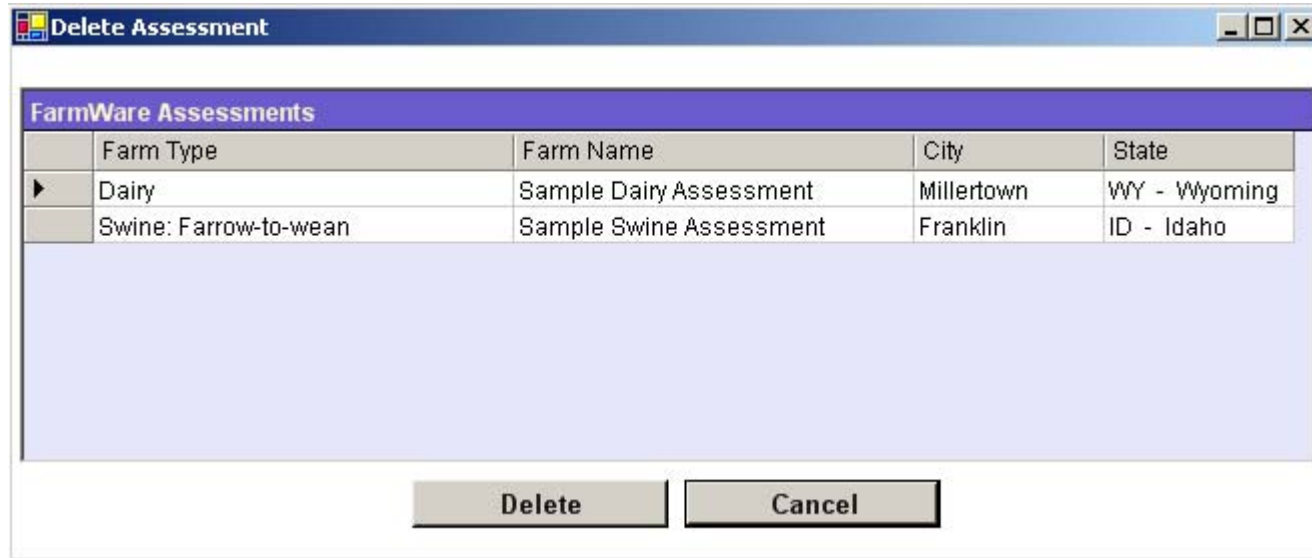
The user can select this option to access a previously created and saved FarmWare 3.0 assessment.



**Figure 4-2. Open Assessment Screen**

#### 4.3      Delete Assessment

The user can select this option to delete a previously created and saved FarmWare 3.0 assessment.



**Figure 4-3. Delete Assessment Screen**

#### 4.4      View/Edit Financial Factors

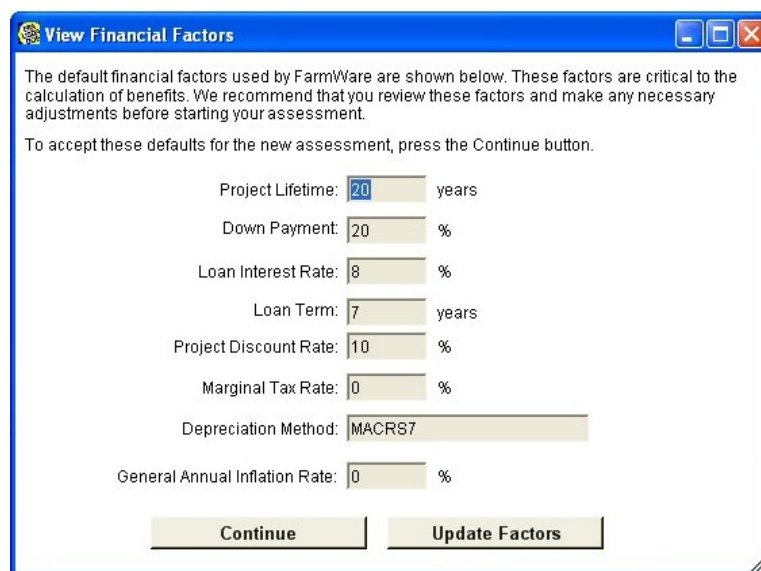
The user can select this option to access the financial factors for the project that is currently opened. Upon clicking on *View/Edit Financial Factors* the user is taken to the Financial Factors screen.

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**View Financial Factors**

The default financial factors used by FarmWare are shown below. These factors are critical to the calculation of benefits. We recommend that you review these factors and make any necessary adjustments before starting your assessment.

To accept these defaults for the new assessment, press the Continue button.

Project Lifetime: 20 years

Down Payment: 20 %

Loan Interest Rate: 8 %

Loan Term: 7 years

Project Discount Rate: 10 %

Marginal Tax Rate: 0 %

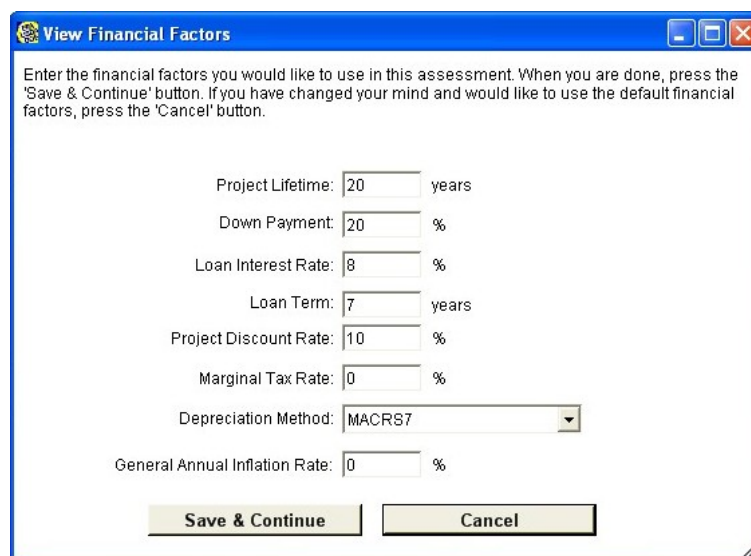
Depreciation Method: MACRS7

General Annual Inflation Rate: 0 %

**Continue**      **Update Factors**

**Figure 4-4. Financial Factors Screen**

The financial factors are critical to the economic calculations in FarmWare. Therefore, it is recommended that the user review the factors before starting the assessment. The Financial Factors screen has default values already input into the assessment. The user can accept the default values and select *Continue* or select the *Update Factors* to change the factors. The user should then select *Save & Continue* or *Cancel*.



**View Financial Factors**

Enter the financial factors you would like to use in this assessment. When you are done, press the 'Save & Continue' button. If you have changed your mind and would like to use the default financial factors, press the 'Cancel' button.

Project Lifetime: 20 years

Down Payment: 20 %

Loan Interest Rate: 8 %

Loan Term: 7 years

Project Discount Rate: 10 %

Marginal Tax Rate: 0 %

Depreciation Method: MACRS7

General Annual Inflation Rate: 0 %

**Save & Continue**      **Cancel**

**Figure 4-5. Financial Factors Update Screen**

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### 4.5 View/Edit Manure Excretion Rate

The user can select this option to access manure excretion rates for the assessment that is currently opened. FarmWare default rates are from published USDA Natural Resources Conservation Service values and the ASAE Manure Production and Characteristics standard D284.1, as shown in Table 4-1. These values are converted to pounds per head per day in Table 4-2.

**Table 4-1. Default Manure Excretion Rates**

	Weight <sup>1</sup>	Manure <sup>2</sup>	TS <sup>2</sup>	VS <sup>2</sup>	Nitrogen <sup>2</sup>	Phosphorus <sup>2</sup>
	Lbs	Lb/d/1000#	Lb/d/1000#	Lb/d/1000#	Lb/d/1000#	Lb/d/1000#
Lactating Cow	1,332	80	10	8.5	0.45	0.07
Dry Cow	1,332	82	11.6	8.1	0.36	0.05
Heifer	1,049	85	10.7	7.77	0.31	0.04
Calf	260	65.8	9.2	7.6	0.32	0.1
Sow: Lactating	436	60	6	5.4	0.47	0.15
Sow: Gestating	436	27.2	2.5	2.13	0.19	0.06
Nursing Pigs	35	106	10.6	8.8	0.6	0.25
Weaned Pigs	90	106	10.6	8.8	0.6	0.25
Feeder Pigs	201	63.4	6.34	5.4	0.42	0.16
Boars	400	20.5	1.9	1.7	0.15	0.05

<sup>1</sup> Average weights are estimated from EPA, U.S. Manure Management Inventory, 2004.

<sup>2</sup> USDA National Resource Conservation Service. Manure Production Nutrient Content Data (as excreted)

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**Table 4-2. Converted Default Manure Excretion Rates**

	Weight	Manure	TS	VS	Nitrogen	Phosphorus
	Lbs	Lb/d/head	Lb/d/head	Lb/d/head	Lb/d/head	Lb/d/head
Lactating Cow	1,332	106.6	13.3	11.3	0.60	0.09
Dry Cow	1,332	109.2	15.5	10.8	0.48	0.07
Heifer	1,049	89.2	11.2	8.2	0.33	0.04
Calf	260	17.1	2.4	2.0	0.08	0.03
Sow: Lactating	436	26.2	2.6	2.4	0.20	0.07
Sow: Gestating	436	11.9	1.1	0.9	0.08	0.03
Nursing Pigs	35	3.7	0.4	0.3	0.02	0.01
Weaned Pigs	90	9.5	1.0	0.8	0.05	0.02
Feeder Pigs	201	12.7	1.3	1.1	0.08	0.03
Boars	400	8.2	0.8	0.7	0.06	0.02

FarmWare calculates the total mass of manure, total solids (TS), volatile solids (VS), nitrogen, or phosphorus generated by any animal type using the following equation:

$$\text{Waste mass (lbs/day)} = \text{Number of Animals} * \text{Weight} * \text{Animal Excretion Rate}/1000$$

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### CHAPTER 5.0: GENERAL INFORMATION TAB

The general information tab has two sections: farm information and climate information. The user must complete the required fields in the farm information section. FarmWare automatically populates the climate information using the state and county entered into the farm information section.

	Temp (F)	Rain (in)
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		
Average / Total		

Figure 5-1. General Information Tab

#### 5.1 Farm Information

There are four required data fields in the farm information section of the **General Information** tab: Type, Name, State, and County. All four fields must be completed to continue with the Assessment. Alternatively, the user may select cancel to return to the Assessment screen.

There are six different farm types available the pull down menu for the Type field: Dairy, Swine: Farrow to Finish, Swine: Farrowing, Swine: Nursery, Swine: Farrowing plus nursery, and Swine: Grow-Finish. FarmWare requires the type of farm because later parameters and data fields in the model change depending on type.

FarmWare requires the State and County because those two fields are used to automatically complete the Climate Information section of the **General Information** tab. The states are listed in the pull down menu. The County pull down menu is only activated once a state has been selected in the State field. Note: FarmWare includes state-level climatological data for Alaska and Hawaii. No specific counties may be selected for these U.S. states.

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### **5.2      Climate Information**

FarmWare uses precipitation, evaporation, and temperature data to calculate methane production and to size liquid stabilization and storage facilities. All uncovered stabilization and storage facilities are required to have the capacity to hold runoff and direct precipitation from the peak storm event. FarmWare 3.0 assumes that the peak storm event is the 25-year/24-hour storm event for dairies and existing swine operations, and the peak storm event for planned (new) swine operations is the 100-year/24-hour storm event for swine operations. These event parameters were selected to be consistent with the design requirements for lagoons in EPA's Effluent Limitations and Guidelines for Confined Animal Feeding Operations. The climate data are from the National Climate Data Center, averaged for all weather stations within a county.

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### CHAPTER 6.0: FARM SETUP TAB

The **Farm Setup** tab has two sections: Manure Collection and Waste Management System Definition. The user enters information about how the animals on the farm are confined and how manure is collected in those confinement areas. The user then selects the conventional waste management system at the farm and the alternative biogas recovery waste management system that is being assessed. The selection options differ between dairy operations and swine operations.

#### 6.1 Dairy

The Farm Setup tab for dairies opens for a new assessment as shown in Figure 6-1.

**FarmWare: dairy test**

**AgSTAR** ENERGY AND POLLUTION PREVENTION

**Farm Setup**

Assessment   General Information   **Farm Setup**   Livestock   Conventional Process Train   Biogas Process Train   Energy Consumption   Costs & Revenues   Report

Enter information about how the animals on the farm are confined and how manure is collected in the confinement areas. Select the conventional waste management system that would be or is present at your farm, as well as the biogas recovery waste management system for which you are conducting this assessment.

**Manure Collection**

Do you keep animals in a barn?:

Outdoor Confinement:

**Waste Management System Definition**

**Conventional Process**

☐ Includes a separator

Liquid/Slurry:

Solid:

**Biogas Process**

☐ Includes a separator

Liquid/Slurry:

Solid:

Digester Type	Waste Stream Total Solids
Covered Lagoon Digester	0.5 – 3 %
Complete Mix Digester	3 – 10 %
Plug Flow Digester	11 – 13 %

<< Previous   Save   Exit   Restore   Next >>

Figure 6-1. Farm Setup Tab (Dairies)

##### 6.1.1 Manure Collection

The user is first asked if the animals are kept in a barn. There are three options to choose from:

- Yes- Flush Barn;
- Yes- Scrape Barn; and
- No.

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A flush barn uses recycled water to collect and transport manure into a storage or stabilization facility. A scrape barn uses a mechanical device to collect and remove manure. If a flush barn is selected, the user can either enter the amount of water used to flush the barn or derive the amount of water used to flush the barn by entering the number of barns, the number of flush tanks per barn, the gallons per flush, and the number of flushes per day. If the user selects a scrape barn, no additional information is required.

### Special Case: California Dairies

California-style dairies are a special style of animal and waste management system in which the herd has access to a free-stall barn without side or end walls but possibly side curtains and an open lot or corral. This type of dairy should be treated as two separate housing areas: a barn and an open lot. The user should indicate what type of manure collection occurs within each separate confinement area (i.e., flushed or scraped manure), and provide detail on the open lot portion of the confinement area in terms of pavement and the time the cattle typically spend within each area.

The user is then asked if there is any outdoor confinement for the animals. There are again three options to choose from: Pasture, Open Lot, or No Outdoor Housing. No additional information is required if Pasture or No Outdoor Housing is selected. If animals are only kept in a pasture then a biogas collection system is not feasible.

### 6.1.2 Conventional Process

The user has four options to selection from in the conventional process: Anaerobic Lagoon with Liquid/Slurry Storage, Combined Treatment and Storage Lagoon, Storage Pond, and Storage Tank.

- **Multi-cell Anaerobic Lagoons (Anaerobic Lagoon with Storage):** Manure and process wastewater is discharged into a primary cell that operates at a constant volume for initial stabilization. Although some additional waste stabilization may occur, the primary function of the final cell is storage. Intermediate cells, if present, also operate at a constant volume to provide additional waste stabilization.
- **Combined Treatment and Storage Lagoons:** Manure, process wastewater, and runoff from open lots are diverted to one large combined treatment and storage lagoon. The lagoon is designed to provide the minimum treatment volume, accumulated solids volume, waste volume, and runoff for the storage period. A solid separator can be selected to reduce the volume of solids that enter the system.
- **Storage Tanks:** A conventional system may store manure and process water in above-ground or in-ground tanks. If there is an open lot on site, runoff is diverted to a separate storage structure, reserving the tank volume for manure and minimal process water. Solids separation can reduce the volume of solids entering the tank.
- **Storage Ponds:** A conventional system may use storage ponds to store manure and process water. If there is an open lot on site, runoff is diverted to the storage pond. Again, solids separation can reduce the volume of solids entering the tank.

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### 6.1.3 Biogas Process

The user may choose one of three options to digest manure at their facility: Complete Mix Digester, Covered Lagoon Digester, and Plug Flow Digester.

- **Complete mix digesters** are above-ground or in-ground vessels that treat slurry manure with a solids concentration in the range of 3 to 10 percent. These structures require less land than lagoons and are heated. Complete mix digesters are compatible with combinations of scraped and flushed manure. FarmWare assumes that complete mix digesters operate at a temperature of 95 to 100 degrees Fahrenheit.

**Special Case: Dairies With Sand Bedding**  
If a dairy has sand bedding, a sand trap is required prior to a digester. This cost is not accounted for in FarmWare.
- **Covered Lagoon Digesters** are used to treat and produce biogas from liquid manure with less than 3 percent solids. Generally, a large lagoon is required, preferably with a depth of at least 12 feet. The volume of the digester equal to the minimum treatment volume appropriate for the volatile solids loading rate in that climate region. Covered lagoons for energy recovery are compatible with flush manure systems in warm climates. Covered lagoons may be used in cold climates for odor control with collected biogas disposal by flaring.
- **Plug Flow Digesters** are heated, rectangular tanks that treat scraped dairy manure with a range of 11 to 13 percent total solids. Swine manure cannot be treated with a plug flow digester due to its typically lower total solids content and lower viscosity. For a plug flow digestion system, FarmWare assumes that milking center process water and manure is diverted to a storage basin and not to the digester in order to maintain the appropriate solids content of the digester influent. For all other systems, FarmWare assumes that milking center process water and manure are discharged to the digester.

### 6.2 Swine

The Farm Setup tab for dairies opens for a new assessment as shown in Figure 6-2.

#### 6.2.1 Manure Collection

The user is first asked how animals are confined and manure is collected. There are six options:

- Flush Barns;
- Open Lot;
- Deep Pit Barns;
- Pull Plug Barns/Pit Recharge Barns;
- Hoop Barns; and
- Pasture.

Flush barns and open lots at swine facilities operate similarly to those at dairy operations, and are described in Section 6.1.

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A deep pit barn stores manure beneath the housing area. The floor of the housing area is a slatted floor through which manure waste falls into the pit where it is stored. Deep pit barns are not viable for biogas recovery.

Pull plug barns/pit recharge barns have smaller pits beneath the housing area that are periodically drained into lagoons. The user must also input the frequency the barn is drained and the water that is used per animal per day for pit recharge or flushing.

Hoop barns are barns that use aluminum hoops and tarps to form a roof. These barns are not designed for longevity and are also not viable for biogas recovery. Pastures are also not viable for biogas recovery.

Digester Type	Waste Stream Total Solids
Covered Lagoon Digester	0.5 – 3 %
Complete Mix Digester	3 – 10 %
Plug Flow Digester	11 – 13 %

Figure 6-2. Farm Setup Tab (Swine)

### 6.2.2 Conventional Process

The user has four options from which to select a conventional (conventional) management system: Anaerobic Lagoon with Liquid/Slurry Storage, Combined Treatment and Storage Lagoon, Storage Pond, and Storage Tank. Each of these liquid/slurry storage and stabilization units are described in Section 6.1.

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#### 6.2.3 Biogas Process

The user may select from two options to define the biogas management system: Complete Mix Digester or Covered Lagoon Digester . Section 6.1 describes these digestion methods.

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### CHAPTER 7.0: LIVESTOCK TAB

There are two sections to the **Livestock** tab: Animals and Manure Placement. In the Animal section, the user is required to enter the types and number of animals confined at the farm. In the Manure Placement section, the user indicates the number of hours daily that the animals spend in the different confinement areas. The maximum number of animals that may be considered for a FarmWare assessment is 32,000.

#### 7.1 Animals

##### 7.1.1 Dairy

There are four dairy animal types that may exist in a FarmWare assessment: Dairy Cow: Lactating, Dairy Cow: Dry, Dairy Heifer, and Dairy Calf. The user first must check the boxes for those animals that are present at the farm. Then the user indicates the number of animals confined and where they are confined at the farm.

Animals On Site	Number Of Animals	Primary Housing	Secondary Housing
<input type="checkbox"/> Dairy Cow: Lactating			
<input type="checkbox"/> Dairy Cow: Dry			
<input type="checkbox"/> Dairy Heifer			
<input type="checkbox"/> Dairy Calf			

☒ Estimate Number of Animals Based on Number of Dairy Cow: Lactating

	Lactating Cow	Dry Cow	Dairy Heifer	Dairy Calf
Barn				
Open Lot				
Pasture				
Milking Center				
Total Hours Per Day				

<< Previous      Save      Exit      Restore      Next >>

Figure 7-1. Livestock Tab (Dairy)

If the user chooses, FarmWare can estimate the number of animals at a farm given the number of lactating dairy cows. For every 100 lactating dairy cow, FarmWare estimates:

- 20 dry cows;
- 30 replacement heifers (15 to 24 months); and
- 30 replacement calves (3 to 14 months).

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#### 7.1.2 Swine

There are six swine animal types that may exist in a FarmWare assessment: Sow: Lactating, Sow: Gestating, Nursing Pigs, Nursery (Weaned) Pigs, Feeder Pigs, and Boars. The user first must select the boxes next to the name of the swine animal type that are considered in this assessment. Then the user enters the number of animals at the facility and selects the confinement type.

If the user chooses, FarmWare can estimate the number of animals at a farm for certain farm types. Table 7-1 presents the number of animals estimated at farrowing farms for every 100 lactating sows.

**Table 7-1. FarmWare Animal Count Estimates for Swine Farms**

Animal	Farrow-to-Finish Operation	Farrow-to-Wean Operation	Farrow-to-Wean Plus Nursery
Sow: Lactating	100	100	100
Sow: Gestating	200	200	200
Nursing Pigs	940	940	940
Nursery (Weaned) Pigs	940	60	940
Feeder Pigs	820	0	0
Boars	0	0	0

FarmWare does not estimate animals grow-finish and nursery operations.

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### 7.2      Manure Placement – Hours in Each Housing Facility

Enter the number of hours the animals spend in each of the confinement facilities. Only the animal types that are checked in the Animals section are available for editing. If the boxes are gray, then the user did not check the boxes off in the animal section above. FarmWare automatically defaults the number of hours in each facility to 24 hours. The total must sum to 24 hours for each animal type. The user must select the *Save* button at the bottom of the screen to update and save the data.

The screenshot shows the 'Livestock' tab in the FarmWare Swine Farm application. The interface includes a navigation bar with tabs: Assessment, General Information, Farm Setup, Livestock (selected), Conventional Process Train, Biogas Process Train, Energy Consumption, Costs & Revenues, and Report. Below the navigation bar is a text box explaining that FarmWare allows up to two confinement areas per animal type and that the maximum number of animals at any one facility is 32,000. The main form is divided into two sections. The top section, 'Animals On Site', lists animal types with checkboxes and input fields for the number of animals and housing. The bottom section, 'Housing', lists confinement areas (Barn, Open Lot, Total) with input fields for the number of animals for each type. At the bottom of the form are buttons for '<< Previous', 'Save', 'Exit', 'Restore', and 'Next >>'.

Animals On Site	Number Of Animals	Housing	Animals On Site	Number Of Animals	Housing
<input type="checkbox"/> Sow: Lactating			<input type="checkbox"/> Nursery (Weaned) Pigs		
<input type="checkbox"/> Sow: Gestating			<input type="checkbox"/> Feeder Pigs		
<input type="checkbox"/> Nursing Pigs			<input type="checkbox"/> Boars		

☒ Estimate Number of Animals Based on Number of Sow: Lactating

	Sow: Lactating	Sow: Gestating	Nursing Pigs	Weaned Pigs	Feeder Pigs	Boars
Barn						
Open Lot						
Total						

<< Previous      Save      Exit      Restore      Next >>

Figure 7-2. Livestock Tab (Swine)

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### CHAPTER 8.0: CONVENTIONAL PROCESS MAP TAB

The **Conventional Process Map** tab diagrams the movement of manure and process water from confinement facilities through its end use. Colored arrows indicate the flow of individual waste streams between the process components. The blue arrows represent wastewater, the orange arrows represent solid waste, and the red arrows represent runoff. For example, Figure 8-1 shows the manure and process water movement from both a milking center and a flush barn into a lagoon system.

The user may click on any of the process unit names in the diagram to review popup screens that show the system design parameters computed or used in FarmWare. The following sections describe the design parameters that FarmWare uses for each process unit.

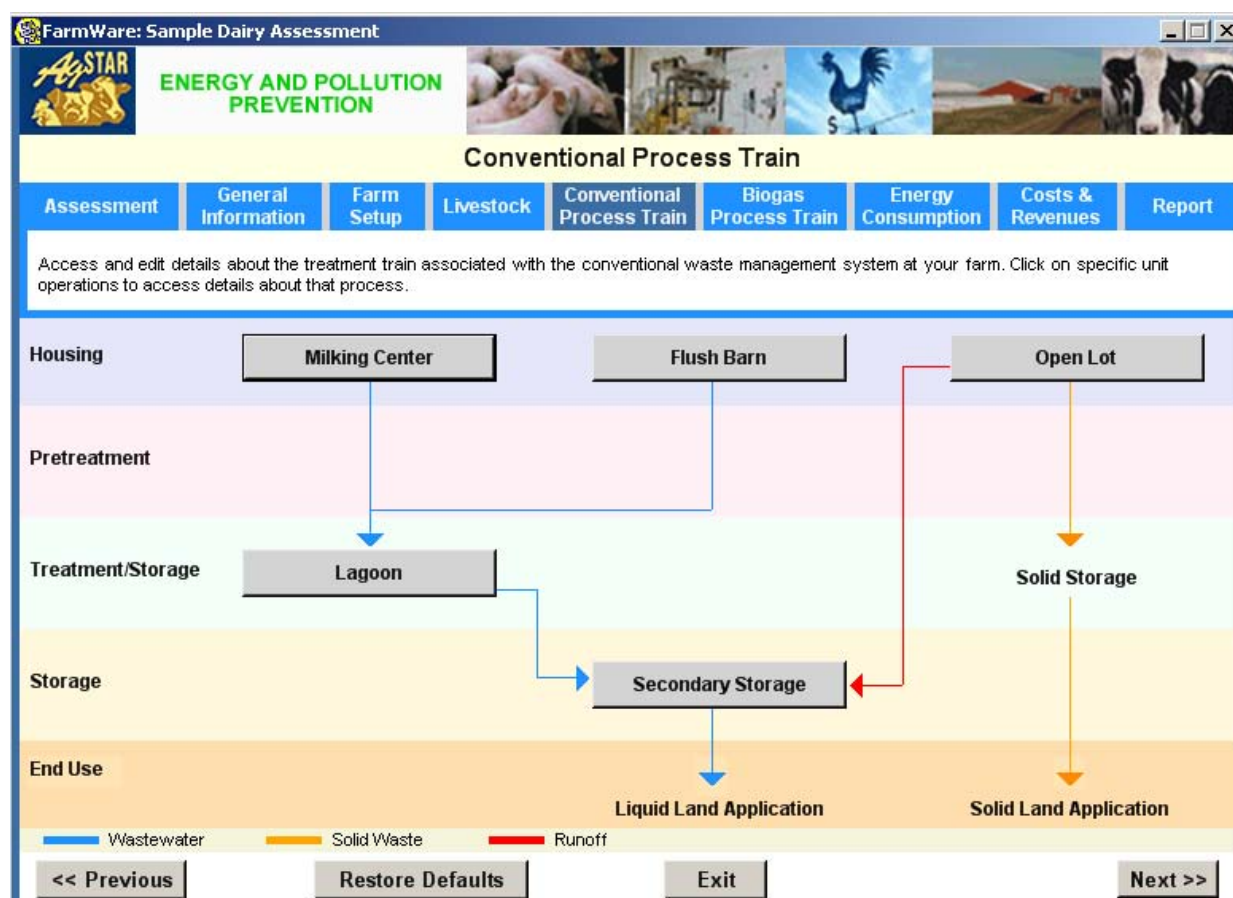


Figure 8-1. Conventional Process Train Screen

#### 8.1 Housing

The housing level presents the confinement areas where manure and process water are generated. There are three categories: Barns, Outdoor Confinement, and the Milking Center (for dairies only).

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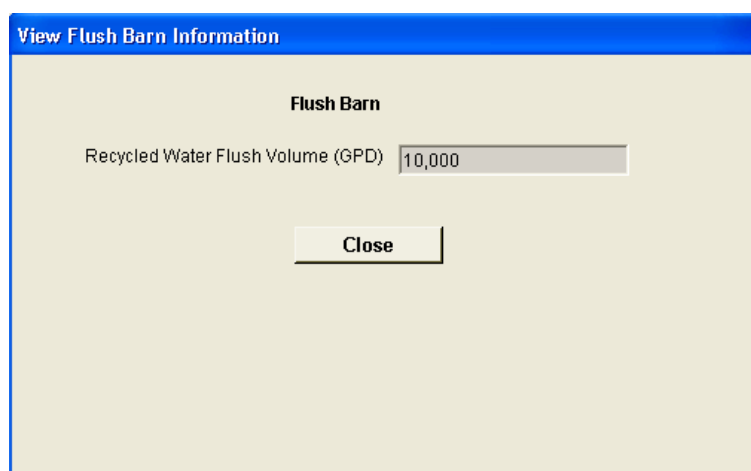
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#### 8.1.1 Barns

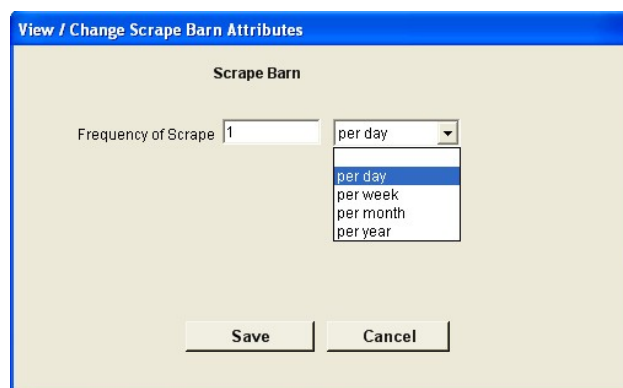
The user may select one of five types of barns: flushed, scraped, pull plug/ pit recharge, deep pit, and hoop barns. For a dairy assessment, the user may select either flushed or scraped barns. For a swine assessment, the user may select flushed, deep pit, pull plug / pit recharge, or hoop barns (note, deep pit and hoop barns are not amenable to digestion). FarmWare 3.0 uses default values to estimate process water volumes and manure generated from each type of housing unit.

**Flush Barns:** FarmWare 3.0 estimates the amount of recycled water used per day for manure removal from a flush barn using default assumptions. FarmWare 3.0 calculates the total water used based on the number of animals that reside in the barn for their primary housing, as entered in the **Livestock** tab. The design view of the Flush Barn screen indicates these default assumptions.



**Figure 8-2. Flush Barn Screen**

**Scrape Barn:** FarmWare 3.0 assumes that a barn with solid waste management is scraped once per day. This is the default for the program, as shown in the design screen. The user may modify this frequency (per day, per week, etc.). The user can edit and click the *Save* button to update. If the user agrees with the default values, then the user can select the *Cancel* button to close the menu.



**Figure 8-3. Scrape Barn Screen**

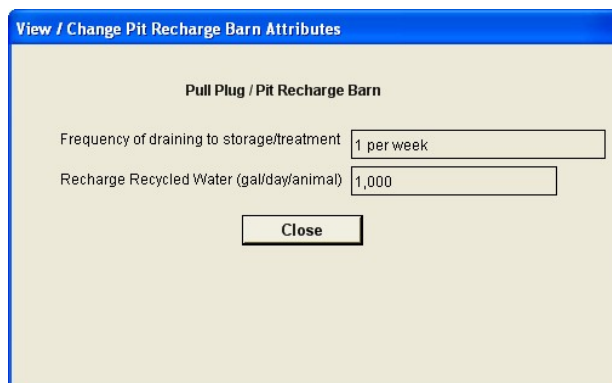
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**Pull Plug / Pit Recharge Barn:** FarmWare 3.0 contains an assumption that pit recharge barns are recharged with an amount of recycled water commensurate with the number and type of swine kept in the barn. The user cannot edit the assumptions on this screen. The user can go back to the **Farm Setup** tab and change the assumptions there. This screen simply shows the user what assumptions were chosen.



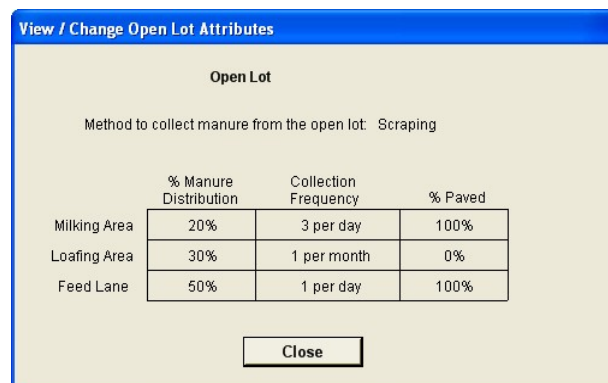
**Figure 8-4. Pit Recharge Barn Screen**

**Deep Pit Barns and Hoop Barns:** Deep pits barns and hoop barns are not viable for biogas recovery. Because they are not compatible with biogas recovery, FarmWare does not calculate biogas recovery under these manure collection options.

#### 8.1.2 Outdoor Confinement

FarmWare considers two options for outdoor confinement : Open Lots and Pasture.

**Open Lot:** Manure can be collected from an open lot by either scraping or flushing. (The user indicates this on the Farm Setup tab.) Once an open lot is selected, FarmWare presents the user with default information assumed for the open lot, including how the manure is distributed in the lot, the collection frequency of each portion of the lot, and the paved percentage of each section of the lot. This information is used to calculate runoff coefficients and to evaluate what portion of manure waste may be directed to a liquid/slurry stabilization system versus storage. The user may edit different parameters describing the open lot in the Farm Setup tab.



	% Manure Distribution	Collection Frequency	% Paved
Milking Area	20%	3 per day	100%
Loafing Area	30%	1 per month	0%
Feed Lane	50%	1 per day	100%

**Figure 8-5. Open Lot Design Parameters Screen**

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Open lots are also a source of runoff. FarmWare assumes that runoff is directed to liquid storage, generally separate from manure. To calculate the amount of runoff per lot, FarmWare assumes the following open lot area per head:

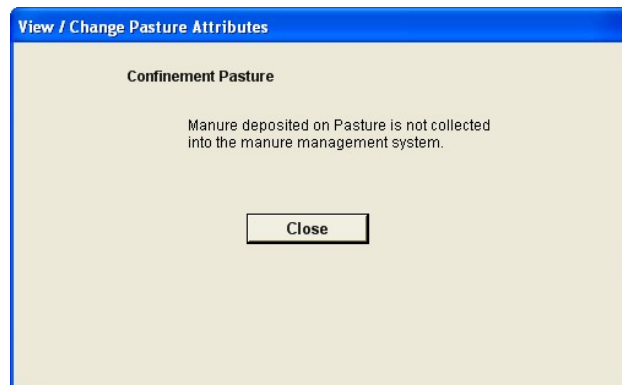
**Table 8-1. Open Lot Area per Animal Assumed by FarmWare**

Animal	Open Lot area (Square feet)
Lactating dairy cow	
Dry dairy cow	460
Dairy heifer	431
Dairy calf	259
Sow: Gestating or Lactating	200
Nursing or Weaned Pigs	75
Finishing / Feeder Pigs	150
Boars	200

<sup>1</sup> Dairy source: "Cost Methodology for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and Effluent Guidelines for Concentrated Animal Feeding Operations." EPA, December 2002. Area required for mature dairy cows is set equal to the areas assumed for mature beef cattle.

<sup>2</sup> Swine source: "Got Barnyard Runoff?" Chris Henry, University of Nebraska-Lincoln and Joe Harner, Kansas State University.

**Pasture:** Manure from a pasture is not collectable and therefore, a static screen appears notifying the user that manure is not collected in the management system when clicking on the *Pasture* button.



**Figure 8-6. Pasture Screen**

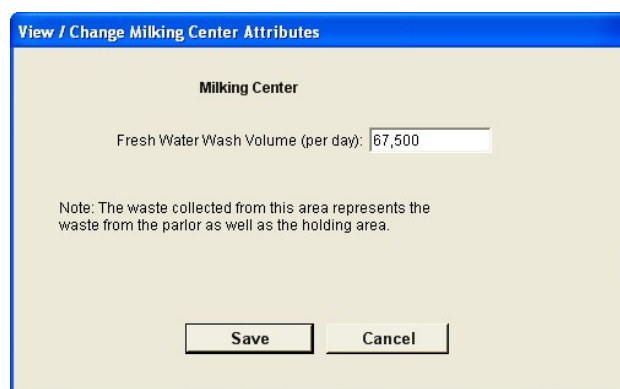
**Milking Center:** A milking center is the facility where lactating dairy cattle are milked. In the Livestock tab, the user provided the number of hours cattle spend at the milking center. In the process map, the user can edit the amount of daily fresh water used to wash both the parlor and holding area and click the *Save* button to update. If the user agrees with the default values, then the user can select the *Cancel* button to close the menu.

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**Figure 8-7. Milking Center Process Water Screen**

### 8.2 Pretreatment

**Solids Separation:** FarmWare assumes that all dairy farms can use some form of solid separation. Swine farms are assumed not to use solid separation due to the very low solids content of the manure. In the Separation design parameter screen, the user can edit the default total and volatile solids separation efficiencies or accept the default values listed in Table 8-2.

**Table 8-2. Solid Separation Types in FarmWare**

Solid Separator	Efficiency	
	Solid Separation (%)	Volatile Solid Reduction (%)
Vibrating Screen	15	15
Screw Press	25	25
Static Inclined Screen	27.5	27.5
Gravity Settling Basin	40	40

### 8.3 Stabilization/Storage

The third stage of the conventional process map is either stabilization or storage, depending on the selections made in the Farm Description screen. Stabilization or storage options vary according to the animal type and the influent total solids, and include lagoons, storage ponds, or tanks. The design parameters for each of these stabilization and storage options are presented below.

#### 8.3.1 Anaerobic Lagoon

The design parameters screen for anaerobic lagoon has many values that the user can customize to the farm including if the lagoon is covered, total volume, surface area, side wall slope, and depth. The default volume and surface area are calculated from the number of animals and the process water used in the system, which were entered in the **Farm Setup** tab and the **Livestock** tab.

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The screenshot shows a software window titled "View / Change Lagoon Attributes". Inside, the "Anaerobic Lagoon" section contains the following fields and controls:

- "Is the lagoon covered?": A dropdown menu with "No" selected.
- "Years Between Sludge Cleanout": A text input field with the value "5".
- "Lagoon slope": A dropdown menu with "3:1" selected.
- "Lagoon depth (ft)": A text input field with the value "10.7".
- "Storage Time": A text input field with the value "90".
- A "Recalculate Surface Area and Volume" button.
- A horizontal separator line.
- "Total Volume (ft3)": A text input field with the value "5,310,729".
- "Surface Area (ft2)": A text input field with the value "470,747".
- "Save" and "Cancel" buttons at the bottom.

Figure 8-8. Anaerobic Lagoon Design Parameters Screen

### 8.3.2 Storage Pond

Either dairy or swine waste may be stored in a storage pond. Storage ponds are earthen structures and not typically covered; therefore, precipitation and runoff enter the pond. The storage pond is assumed to be a minimum of 12 feet deep with a 2:1 side slope.

By clicking the *Storage Pond* button, the user has the option to update the following storage pond design values: total volume, surface area, storage time, and pond depth. The default volume is calculated from the daily process water used in the system, which was entered in the **Farm Setup** tab, the manure generated, and the precipitation.

The screenshot shows a software window titled "View / Change Storage Pond Attributes". Inside, the "Storage Pond" section contains the following fields and controls:

- "Total volume (ft3)": A text input field with the value "6,083,264".
- "Surface area (ft2)": A text input field with the value "515,652".
- "Years between sludge cleanout": A text input field with the value "5".
- "Pond storage time (days)": A text input field with the value "90".
- "Pond depth (ft)": A text input field with the value "12".
- "Save" and "Cancel" buttons at the bottom.

Figure 8-9. Storage Pond Design Parameters Screen

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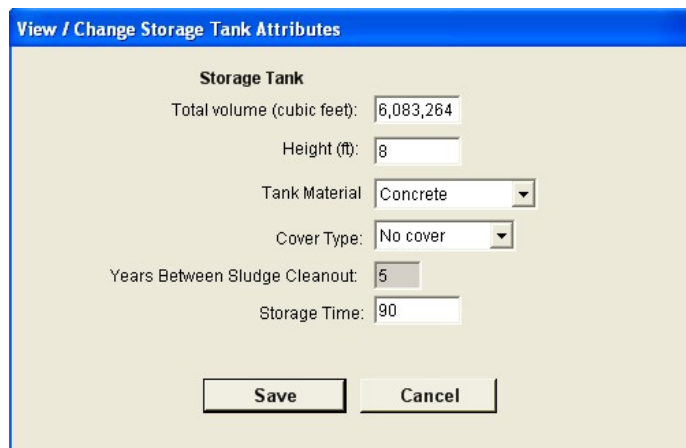
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#### 8.3.3 Storage Tank

Either dairy or swine waste may be stored in a storage tank. By clicking the *Storage Tank* button, the user has the option to update the following storage tank design parameters: total volume, height, tank material (concrete, fiberglass, or steel), cover type (flexible or hard top or none), and storage time. The default volume is calculated from the daily process water used in the system, which was entered in the **Farm Setup** tab, the manure waste generated, and the precipitation if there is no cover.



**Figure 8-10. Storage Tank Design Parameters Screen**

#### 8.3.4 Solid Storage

Manure is collected as a solid or semi-solid from infrequently scraped open lots and from solid separation. FarmWare assumes collected solid and semi-solid manure is stacked onsite, and then diverted to solid land application. This button does not produce a popup screen.

#### 8.3.5 Methane Generation from Conventional Manure Stabilization and Storage

FarmWare uses the methodology presented by the Intergovernmental Panel on Climate Change's (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2006) for estimating methane emissions from storage tanks and ponds and lagoons to estimate methane emissions from conventional systems (i.e., not biogas recovery systems). This is the methodology used for the EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. The calculation of emissions requires the following information:

- Animal population on site;
- Farm location;
- Amount of volatile solids produced (excretion rate by animal type times animal population);
- Methane producing potential of the volatile solids (by animal type); and
- Extent to which the CH<sub>4</sub> producing potential is realized for the particular type of manure management system (which varies by state and manure management system).

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There are three steps used in this methodology:

- 1) Quantify the influent volatile solids.
- 2) Assign the methane conversion factor relevant to the liquid/slurry system, animal type, and state.
- 3) Calculate the methane from the system:

$$\text{Methane}_{\text{animal group}} = [\text{VS} \times B_o \times \text{MCF}_{\text{animal, system, state}} \times 0.662] * 2.205$$

where:

Methane <sub>animal group</sub>	=	methane emissions for that animal group (kg CH <sub>4</sub> /yr)
Population	=	annual average state animal population for that animal group (head)
VS	=	total volatile solids produced annually per animal (kg/yr/head)
B <sub>o</sub>	=	maximum methane producing capacity per kilogram of VS (m <sup>3</sup> CH <sub>4</sub> /kg VS)
MCF <sub>animal, state</sub>	=	weighted MCF for the animal group, waste management system, and state
0.662	=	conversion factor of m <sup>3</sup> CH <sub>4</sub> to kilograms CH <sub>4</sub> (kg CH <sub>4</sub> /m <sup>3</sup> CH <sub>4</sub> )
2.205	=	conversion of kilograms to pounds

FarmWare calculates influent volatile solids based on the user inputs and NRCS manure excretion rate estimates for volatile solids. Additionally, FarmWare uses B<sub>o</sub> that were independently derived for FarmWare, rather than the values used for the Manure Management Greenhouse Gas Inventory methodology.

### 8.4 Storage

#### 8.4.1 Liquid/Slurry Storage

Liquid manure and wastewater may be stored in a storage basin after primary stabilization or storage occurs. In addition to receiving effluent from primary stabilization and storage, the storage pond directly collects runoff from open lots. FarmWare assumes liquid waste is stored here until it may be land applied. (Note: If there is a storage pond in the stabilization and storage level, then FarmWare assumes there is no additional storage).

As with storage ponds, liquid/slurry storage basins are not typically covered, and therefore allow precipitation and runoff to enter the pond. The storage pond is assumed to be a minimum of 12 feet deep with a 2:1 side slope.

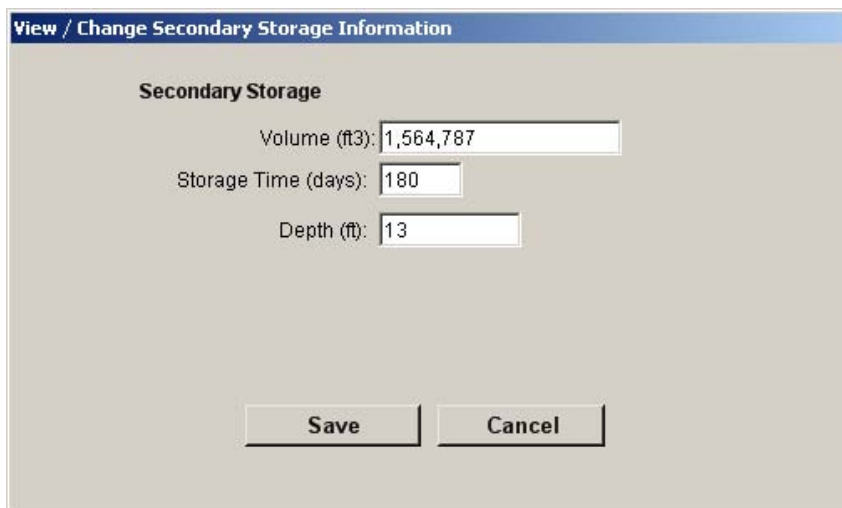
By clicking the *Storage Pond* button in the storage level of the process train, the user has the option to update the following storage design parameters: total volume, surface area, pond storage time, and pond depth. The default volume is calculated from the daily process water used in the system (entered in the **Farm Setup** tab), the manure generated, the default accumulated sludge, and the precipitation.

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View / Change Secondary Storage Information

**Secondary Storage**

Volume (ft3): 1,564,787

Storage Time (days): 180

Depth (ft): 13

Save Cancel

**Figure 8-11. Liquid/Slurry Storage Design Parameters Screen**

#### 8.5 End Use

Stabilization and storage of manure and wastewater generates liquid and solid waste that may be land applied. FarmWare's process diagrams show land application buttons at the end of each waste stream to indicate the final destination of these waste streams. These buttons do not produce a popup screen.

#### 8.6 Restore Defaults

If at any time the user would like to erase all the changes the user has made to the conventional process train, the user can select the *Restore Defaults* button at the lower part of the **Conventional Process Train** tab. However, it is important to note that the *Restore Defaults* button restores ALL of the process train's values. The user cannot partially restore some of the defaults.

#### 8.7 Editing Process Train Defaults

The user may edit the process train default values by clicking on the various unit buttons in the various levels of the **Conventional Process Train** tab. Once the user has accessed the units, the user must select the *Save* button to confirm that the default values have been updated and saved. If the user does not want to save the changes, the user must select the *Cancel* button.

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### CHAPTER 9.0: BIOGAS PROCESS MAP

The **Biogas Process Map** tab illustrates how the biogas recovery and utilization system would be integrated into the conventional manure management system. Colored arrows indicate the flow of individual waste streams through the process units. The blue arrows represent wastewater, the orange arrows represent solid waste, and the red arrows represent runoff. For example, as shown in Figure 9-1, wastewater flows from both the milking center and the flush barn into the separator preceding the covered lagoon digester.

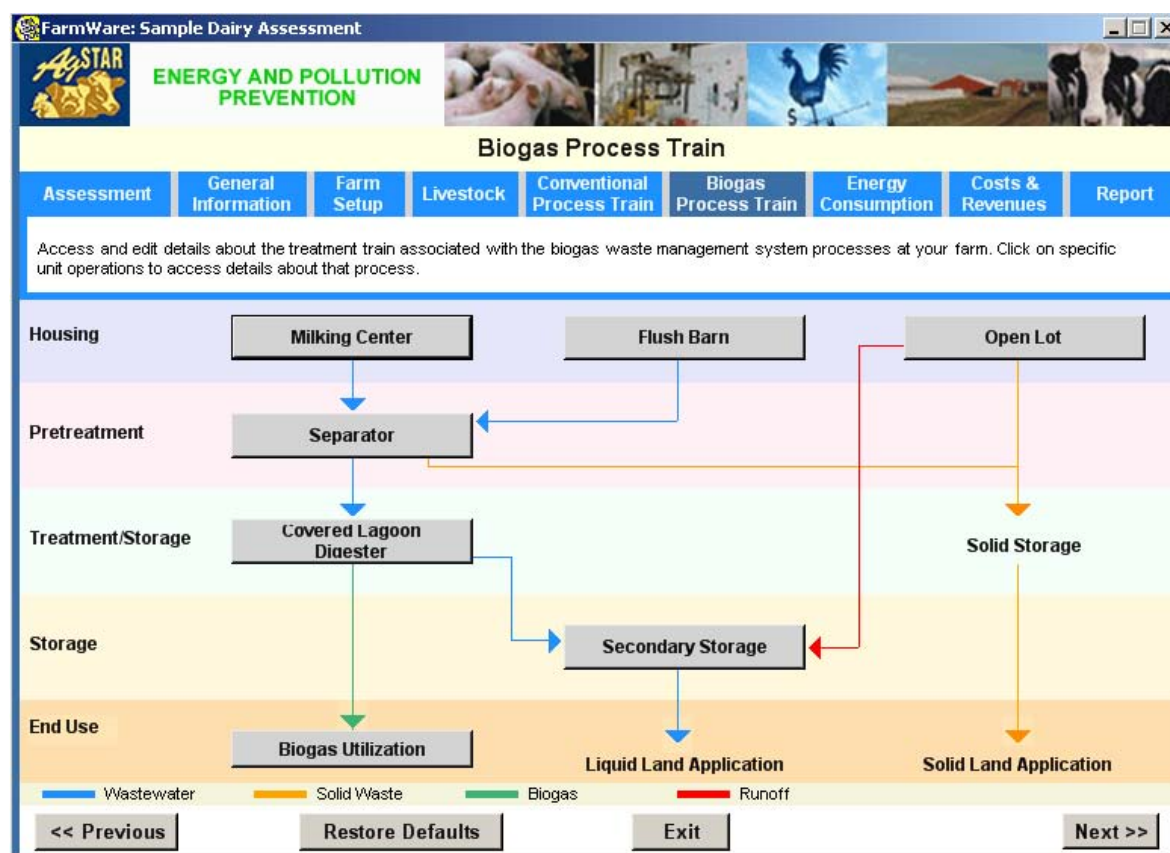


Figure 9-1. Biogas Process Train Screen

#### 9.1 Housing

The housing level presents the confinement areas where manure and process water are generated. There are three categories: Barns, Outdoor Confinement, and the Milking Center (for dairies only). The confinement areas for the biogas recovery system are identical to the conventional system for a particular assessment (i.e., the user may not change confinement options within a single assessment). These confinement areas are described in Section 8.1.

#### 9.2 Pretreatment

**Solids Separator:** FarmWare assumes that all dairy farms may have some form of solid separation. Swine farms are assumed not to have solid separation due to the very low solids content of the manure. The user can access the solid separator design screen by clicking this box in the process map. In this

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screen, the user can specify the type of separator, solid separation efficiency and volatile solid separation efficiency. Additional detail on this screen is provided in Section 8.2.

### 9.3 Digestion

In the stabilization/storage level, the available digestion options depend on the animal type and the percent total solids in the incoming waste, and include covered lagoon, complete mix, and plug flow digestion.

**Table 9-1. Applicable Total Solids Content of Influent to Digestion**

% Total Solids <sup>1</sup>	Type of Digestion		
	Covered Lagoon	Complete-Mix	Plug Flow <sup>2</sup>
0.5% - 3%	Yes	Yes	No
3% - 10%	No	Yes	No
10% - 13%	No	No	Yes

<sup>1</sup> Before separation to remove course solids

<sup>2</sup> Because of the required solids content for Plug Flow Digestion, this technology is not appropriate for swine farms.

**Table 9-2. Default Design Parameters for Digesters**

Animal Type	Digester Type	Minimum Depth Ft	Side Slope	Minimum HRT <sup>1</sup> (Days)	Solids Content Range	
					Min %	Max %
Dairy	Ambient Temperature Covered Lagoon	12	2	Climate Dependent	0.5	3
Dairy	Plug Flow	8	2	20	11	14
Dairy	Complete Mix	12	0	20	2.5	10
Swine	Ambient Temperature Covered Lagoon	12	2	Climate Dependent	0.5	3
Swine	Complete Mix	12	0	20	2.5	10

<sup>1</sup> USDA NRCS Conservation Practice Standards Codes: Conservation Practice Standard: Anaerobic Digester - Anaerobic Digester (No.) Code 365; and Conservation Practice Standard: Anaerobic Digester, Controlled Temperature (No.) 366.

#### 9.3.1 Covered Lagoon Digester

Both dairy and swine operations may select a covered lagoon digester for biogas production and capture from manure and associated wastewater. Covered lagoon digestion requires that the influent waste must be between 0.5 and 3 percent total solids. The FarmWare design of the covered lagoon digester follows the guidelines set forth in NRCS Conservation Practice Standard 365, which includes the determination of the minimum treatment volume based on the smaller of two values: the regional hydraulic retention time or the volatile solids loading rate. The resulting volume is presented in the covered lagoon digester screen. The user may edit the final volume or the surface area, depth, or slope.

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**View / Change Covered Lagoon Digester Information**

**Covered Lagoon Digester**

Total Volume (ft3): 2,038,144

Surface Area (ft2): 147,456

Lagoon Depth (ft): 12

Lagoon Slope: 2:1

Biogas Production (ft3/day): 105,908

HRT (days): 369

Recalculate Surface Area and HRT

Note: all covered lagoons are assumed to be bank-to-bank.

Save Cancel

**Figure 9-2. Covered Lagoon Digester Design Parameters Screen**

### 9.3.2 Complete Mix Digester

Both dairy and swine operations also may select a complete mix digester for biogas production and capture from manure and associated wastewater. Complete mix digestion requires that the influent waste must be between 2.5 and 100 percent total solids. The FarmWare design of the complete mix digester follows the guidelines set forth in NRCS Conservation Practice Standard 366. The resulting volume is presented in the complete mix digester screen by clicking on the *Complete Mix Digester* button. The user may edit the final volume or the characteristics of the digester such as the retention time, the minimum depth, cover type, diameter, surface area, and the amount of biogas produced.

**View / Change Complete Mix Digester Attributes**

**Complete Mix Digester**

Hydraulic retention time (days): 20

Depth of the digester (ft): 10

Diameter of the digester (ft): 1,350.21

Total volume of the digester (cf): 143,183.3

Surface area of the digester (cf): 106.05

Biogas production (cf per day): 23,954.46

Recalculate Diameter and Surface Area

Save Cancel

**Figure 9-3. Complete Mix Digester Design Parameters Screen**

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#### 9.3.3 Plug Flow Digester

Plug flow digestion is only feasible at dairy farms. Plug flow digestion requires that the influent waste must be between 11 and 14 percent total solids. The design of the plug flow digester follows the guidelines set forth in NRCS Conservation Practice Standard 366. In order to achieve this total solids content, milking center waste may have to be diverted around the digester and into a liquid storage basin. The resulting plug flow digester volume is presented in the plug flow digester screen by clicking on the *Plug Flow Digester* button. The user may edit the final volume or the characteristics of the digester such as the length/width ratio, retention time, the minimum depth, digester top, surface area, and the amount of biogas produced. FarmWare assumes that a screw press solid separator always follows a plug flow digester.

**View / Change Plug Flow Digester Information**

**Plug Flow Digester**

Length/Width Ratio (LM):

HRT:

Depth (feet):

Top:

Available volume (ft3):

Available Biogas (ft3/day):

Surface Area (ft2):

**Figure 9-4. Plug Flow Digester Design Parameters Screen**

#### **Converting a Conventional Liquid Waste Process to Plug Flow Digestion**

When converting an existing conventional system to a plug flow digester, a farm may have to reduce bedding and process water use.

#### 9.3.4 Methane Generation from Digestion Systems

To estimate biogas production, FarmWare uses the model proposed by Chen and Hashimoto (1978) to describe the kinetics of methane fermentation:

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$$Y_v = \left( \frac{B_0 * VS}{\theta} \right) \left[ 1 - \left( \frac{K}{\theta \mu_m - 1 + K} \right) \right] \quad (1)$$

where:

- $Y_v$  = volumetric methane production, L CH<sub>4</sub> per influent volume/day
- VS = influent total volatile solids (TVS) concentration, grams per influent volume/day
- $B_0$  = ultimate methane yield, L/g TVS added as  $\theta$  approaches infinity
- $\theta$  = retention time, days
- $\mu_m$  = maximum specific microbial growth rate, days<sup>-1</sup>
- K = kinetic parameter, dimensionless

Equation 1 is a modification of the Contois model (Contois, 1959), a model that Chen and Hashimoto suggest has the advantages of and generally avoids the disadvantages of the more widely used Monod model.

Chen and Hashimoto defined the relationship between  $\mu_m$  and temperature for temperatures between 20 °C and 60 °C based on the analysis of data from several sources as follows:

$$\mu_m = 0.013(T) - 0.129 \quad (2)$$

Hashimoto also proposed equations 3 and 4 to describe the relationships between K and  $S_0$  for dairy (Hashimoto, 1982) and swine manures (Hashimoto, 1984):

$$K_{\text{dairy}} = 0.8 + 0.016 \exp(0.06 * VS_0) \quad (3)$$

$$K_{\text{swine}} = 0.6 + 0.0206 \exp(0.051 * VS_0) \quad (4)$$

where:

- $VS_0$  = influent total volatile solids concentration per influent volume, kg/m<sup>3</sup>
- $K_{\text{dairy}}$  less than or equal to 1.64
- $K_{\text{swine}}$  less than or equal to 1.2

FarmWare estimates energy production available from the digester (btu) using the following eight steps:

Step 1)      Calculate the influent VS.

Influent VS needs to be in terms of kilograms per influent flow volume:

$$\text{Influent VS} = VS \text{ (kg/m}^3\text{)}$$

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Step 2)      Identify the  $B_o$  relevant to this farm.

### $B_o$ Values Assumed for FarmWare

Animal	$B_o$
Grow-Finish	0.48
Farrowing	0.3525
Farrow-Finish	0.3525
Nursery	0.48
Farrowing plus nursery	0.3525
Dairy	0.304

Step 3)      Calculate the hydraulic retention time ( $\theta$ ) for this system.

**Table 9-3. Hydraulic Retention Times Assumed for Digesters in FarmWare**

Digester Type	
Plug Flow	20 days
Covered Lagoon	Climate Dependent
Complete Mix	20 days

Step 4)      Calculate K

The equation to calculate K varies by farm type.

$$\begin{aligned} K_{\text{dairy}} &= 0.8 + 0.016 \exp(0.06 * (VS \text{ kg/m}^3)) \\ K_{\text{swine}} &= 0.6 + 0.0206 \exp(0.051 * VS \text{ kg/m}^3) \end{aligned} \quad (5)$$

Where:  $VS \text{ (kg/m}^3\text{)} = \text{Influent VS concentration, kg/m}^3$

Step 5)      Calculate  $\mu_m$

$$\mu_m = 0.013(T) - 0.129$$

Where  $T =$

*For Covered lagoons digesters: the average monthly ambient temperature for that county and state identified in the General Information Tab in Celsius = (Fahrenheit – 32)/1.8, or 20 degrees C, whichever is higher.*

*For Plug Flow and Complete Mix digesters:  $T = 100$  degrees F.*

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Step 6)      Calculate the monthly methane production from the system:

$$\text{Methane per volume} = \left( \frac{B_0 * VS}{\theta} \right) \left[ 1 - \left( \frac{K}{\theta \mu_m - 1 + K} \right) \right] \quad (6)$$

where:      Methane per volume ( $Y_v$ ) = methane production, cubic meters CH<sub>4</sub> per cubic meters influent  
VS = Influent VS, kilograms/m<sup>3</sup>  
 $B_0$  = ultimate methane yield, cubic meters/kilogram  
         = retention time, days  
 $\mu_m$  = maximum specific microbial growth rate, days<sup>-1</sup>  
K = kinetic parameter, dimensionless, calculated above.

Step 7)      Estimate Biogas Volumetric Production per month

### Dairy

For Dairy operations, 57.5% of biogas volume is assumed to be methane.

Therefore, *Biogas Generation per Month (cubic feet/month) = Methane per month (cubic feet/month)/0.575*

### Swine

For Swine, 68.5% of biogas volume is assumed to be methane.

Therefore, *Biogas Generation per Month (cubic feet/month) = Methane per month (cubic feet/month)/0.685*

Step 8)      Estimate Biogas Btu Production per month

Conversion of volume of methane gas to Btu based on the lower heating value of 923 Btu/ft<sup>3</sup>.

*Biogas Btu Production per month = Methane biogas per month (cubic feet/month) \* 923 Btu/ft<sup>3</sup>*

## 9.4 Storage

### 9.4.1 Digester Effluent Storage

FarmWare assumes that the effluent from all types of digesters will be stored in an earthen storage pond until disposal. Typically, these storage ponds are not covered and accumulate incident precipitation and runoff from open lots. Storage ponds are assumed to be a minimum of 12 feet deep with a 2:1 side slope.

By clicking the *Storage Pond* button, the user has the option to update the following storage pond design parameters: total volume, surface area, storage time, and depth. The default volume is calculated from the daily process manure and wastewater used in the system, which was entered in the **Farm Setup** tab, and the regional precipitation.

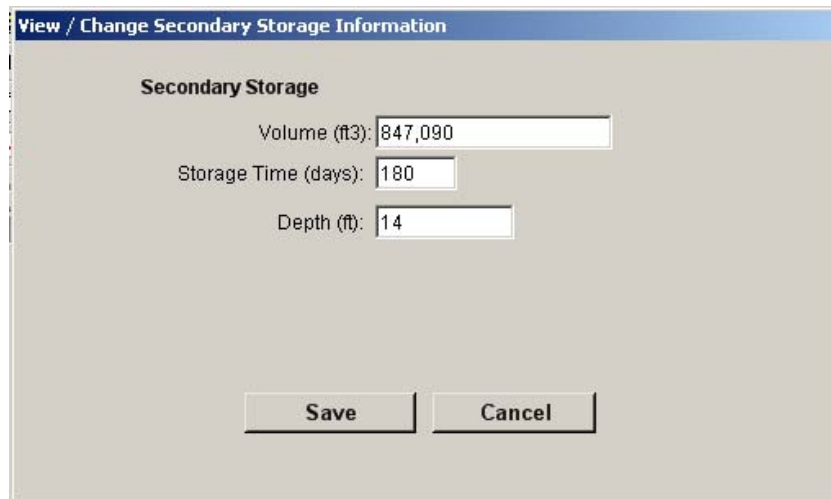
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For existing farms, after FarmWare calculates the approximate volume requirements for the liquid/slurry storage basin under the biogas scenario, FarmWare compares this volume to any existing basin at the farm to determine if the existing basin may be used for storing digested wastes under a biogas scenario. If the basin is large enough, FarmWare does not include costs for the secondary liquid/slurry storage basin in the cost analysis.



**Figure 9-5. Liquid/Slurry Storage Design Parameters Screen**

#### 9.5      End Use

Stabilization and storage of manure and wastewater generates liquid and solid waste that may be land applied. FarmWare's process train screens show land application buttons at the end of each waste stream to indicate the final destination of these waste streams. These buttons do not produce a popup screen.

Clicking on the *Biogas Utilization* button will bring up the Methane Shack: Biogas Utilization screen, which provides detail on the recovered biogas and potential use of the biogas. There are four possible methane options considered by FarmWare; use as a fuel for engine-generator sets, boilers, or furnaces, and flaring. If an engine-generator is selected, the user may consider the FarmWare-calculated "Recommended Engine-Generator Size" as a minimum size that will accommodate the expected biogas recovery. To size the actual system, the user should consult with a qualified engineer to study the site-specific factors that will influence sizing the engine-generator.

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**View / Change Biogas Utilization Information**

**Methane Shack: Biogas Utilization**

Average Daily Biogas Production (ft3/day): 75,425

Recovery Operation: 95% - Best Operation  
90% - Good Operation  
85% - Fair Operation

Recovery Component: Boiler  
Engine-generator

Recommended Engine-Generator Size (kW): 180

Select Engine-Generator Size (kW): 180

Thermal Conversion Efficiency (%): 30

Save Cancel

**Figure 9-6. Biogas Utilization (Methane Shack) Screen**

#### 9.6 Restore Defaults

If at any time the user would like to erase all the changes the user has made to the biogas process train, the user can select the *Restore Defaults* button at the lower part of the **Biogas Process Train** tab. The *Restore Defaults* button restores ALL of the default values. The user cannot partially restore some of the defaults.

#### 9.7 Editing Biogas Process Train Defaults

The user may edit the biogas process train default values by clicking on the various unit buttons in the **Biogas Process Train** tab. Once the user has accessed the units, the user must select the *Save* button to confirm that the default values has been updated and saved. If the user does not want to save the changes, the user must select the *Cancel* button.

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### CHAPTER 10.0: ENERGY CONSUMPTION TAB

The Energy Consumption tab collects information about the use and consumption of energy on the farm. The user will be asked for monthly energy consumption and costs, as well as the energy sources that the biogas will replace.

#### 10.1    Energy Source Replacement

The user will be prompted from a pull down menu to identify which energy source will be replaced with biogas. There are five options to choose from: electricity only, cogeneration of electricity and heat, fuel oil, propane (LPG), or none.

**"Electricity only"** means that the recovered biogas is used only as fuel to generate electricity. The default value for the thermal conversion efficiency, which can be seen by clicking on the *Biogas Utilization* button on the **Biogas Process Train** tab, is 30%; however, the user may edit this percentage to within reasonable limits. A lower practical limit is 15%, and it is unlikely that a system can achieve more than 40% efficiency. (You may edit this field to values between 1 and 60%.)

**"Fuel oil" or "Propane (LPG)"** means that the recovered biogas will be used to replace fuel oil or propane for water or space heating or both. The amount of fuel oil or LPG that can be replaced by using biogas depends on two things: the need for digester heating, the energy conversion efficiency that can be achieved with biogas combustion, and the on-farm demand for thermal energy.

#### A Note on Cogeneration

FarmWare assumes that 100 percent of the propane or fuel oil is available for replacement by recovered heat. If there are physical limitations to 100 percent replacement, then the heat recovery (and revenue estimates) will be less than what FarmWare indicates.

#### If Your Farm Uses Natural Gas

If the user is replacing natural gas with biogas the user might consider using fuel oil as a surrogate. Natural gas costs about 20% higher than fuel oil per btu.

Department of Energy <http://www.eia.doe.gov/emew/mer/pdf/pages/sec9.pdf>

**"Cogeneration"** Cogeneration means that the recovered biogas will be used to generate electricity, and the waste heat from the engine-generator will be captured. The heat from the engine after digester heating requirements are satisfied is recovered and used to replace fuel that would have been used for heat generation at the farm. If cogeneration is selected, the user is then prompted to pick which heating fuel it will replace: fuel oil or propane (LPG).

#### 10.2    Historic Use and Cost

The Energy Consumption screen prompts the user to provide historical energy use and cost by month for one year. FarmWare uses these data to calculate an average cost per unit of electricity or fuel. The user can use the scroll bar to the right of the months to scroll through all of the months. The user only needs to complete the historical energy for the source or sources that may be replaced with biogas energy.

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### 10.2.1 Electricity

The user can enter the amount of electricity used historically and the cost by month. The user should enter any available historical data. FarmWare records energy use in units of kWh/month and cost must be in units of \$/month. The monthly cost of electricity should exclude demand and fixed charges. In the historical data, the user should include the electricity usage affiliated with the source with which you would like to offset. If the user chooses to participate in a electric utility program, the historical rate entered here represents the expected future cost to the user of electricity. This does not represent the cost the utility will pay the user for electricity from the user, which is requested on the following screen "Costs and Revenues."

### 10.2.2 Propane (LPG)

The user can enter the amount of propane used historically and the cost by month. FarmWare collects these data in units of gallons/month and cost must be in units of \$/month.

### 10.2.3 Fuel Oil

The user can enter the amount of fuel oil used historically and the cost by month. FarmWare collects these data in units of gallons/month and cost must be in units of \$/month.

## 10.3 Energy Cost

If the user has entered any historical data and if there is at least one instance of usage and one instance of cost, the user can select the *Calculate* button to have FarmWare calculate an average cost for energy. If no historical data are available, the user must estimate energy cost in this field. This cost should reflect what the user expects to pay for each energy source (e.g., \$/kWh, \$/gallon).

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### CHAPTER 11.0: COSTS AND REVENUES TAB

The Costs and Revenues tab is divided into three sections: Revenue from Electric Utility Programs, Other Revenue, and Installed Project Costs. This tab also allows the user to indicate if the farm has additional revenue or costs. The user can elect to account for any funding assistance or can assign a cost-savings associated with odor control, fiber utilization, nutrient management planning, or other sources. The screen also presents the calculated capital costs of the proposed biogas recovery system for review. The user can elect to edit these capital and annual costs also.

#### 11.1 Revenue from Utility Contract Programs

The user can select from three options for the Electricity Utility Programs from the pull down menu. Those three options are: net metering, sell all, or surplus sales. The types of programs available vary by state. If the user is interested in pursuing one of these options, the user should contact their state utility commission for more information.

#### 11.2 Other Revenue

The user can elect to include other sources of revenue. Included are the value of grants and other types of financial assistance received, and this value is deducted from the capital cost used in the financial analysis. The user also can enter annual benefits, such as cost-benefits from fiber sales/bedding replacement, odor control, and/or other benefits.

#### 11.3 Installed Project Costs

The Installed Project Cost table shows the estimated capital costs and annual operating and maintenance costs for a biogas recovery project. The capital costs are one-time costs initially incurred for construction and equipment. FarmWare estimates the average project costs for each digestion system based on actual and projected project costs provided to EPA as part of biogas recovery programs. All costs are normalized to the year 2005.

##### 11.3.1 Capital Cost

In FarmWare, capital costs are the costs the construction and equipment costs initially incurred to assemble the system and are one-time costs. The sum of these costs, which is the total investment required, is used to calculate the annual loan payment that would be required. Grants and cost share money indicated in the Costs and Revenue screen are deducted from the capital cost. FarmWare assumes that the rate of return and the loan term are the same for both internally provided and borrowed capital.

##### 11.3.2 Operating and Maintenance Cost

FarmWare defines the operating and maintenance cost as being the sum of the costs that are routinely incurred after the system is in operation. These are recurring costs such as the cost of routine engine-generator set maintenance and repair. FarmWare assigns an operating and maintenance cost of 5% of the total project capital cost before any grants or cost share costs are deducted from the capital cost.

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### CHAPTER 12.0: REPORTS TAB

After the user has entered all of the data describing the farm and the manure management processes at the farm, FarmWare generates a report summarizing these data and the feasibility assessment. The report will have the name of the farm and the location in the upper left hand corner of each page. In addition, for easy reference, the version of FarmWare and the date the report was opened is printed at the bottom of the page with the page number.

From the Reports tab, the user can select any of 10 buttons to view, print, or export the report. By clicking on the *View Entire Report* button the entire report will open in another screen. By clicking on either the *View the Executive Summary* button or the other *View Section # buttons*, the corresponding section of the report will pop up. Only one section or the entire report can be open at one time. To return to the **Report** tab, select the "X" button at the uppermost right hand corner of the screen.

The user can navigate the report using the arrows at the top of the page. While reviewing any individual section or table, if the user would like to bookmark a table, the user can select anywhere on the table and the table will appear in an additional window. The user may toggle between the report and the various tables by clicking on the tabs in the Windows task bar.

#### **Print**

The user has the option to print the entire report by clicking on the *Print Entire Report* button. Individual sections cannot be printed.

#### **Export**

The user has the option to export the entire report by clicking on the *Export Entire Report* button. FarmWare can export the report in the following formats: Crystal Reports (\*.rpt), Adobe Acrobat (\*.pdf), Microsoft Excel (\*.xls) (either the whole report or just the data), Microsoft Word (\*.doc), or Rich Text Format (\*.rtf). When exportation is complete, a message indicating "Export completed" will pop up.

#### **Close**

At any point, the user may return to the FarmWare interface by closing the report window using the 'X' button in the top right hand corner of the report window.

### **12.1    Executive Summary**

The Executive Summary identifies basic information about the farm, the conventional manure management system, and the proposed biogas system. The executive summary also includes three tables as shown in Figure 12-1.

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### **Table ES-1:    Assessment of Financial Feasibility of Modifying the Conventional Manure Management System to Capture and Utilize Biogas**

This table includes the total capital investment required, annual revenue from the recovery and use of biogas, total annual costs, simple payback, estimated average annual net income before taxes, and the net present value. Total annual costs include operating and maintenance costs as well as annual taxes and insurance (estimated at 5% capital costs).

### **Table ES-2:    Summary of Biogas System Performance Estimates**

This table includes the estimated potential and estimated value of biogas production and electricity generation.

### **Table ES-3:    Environmental Performance Comparison**

This table summarizes the amount of methane that generated from the system. The table also displays the changes in ammonia and chemical oxygen demand during digestion based on differences between digester influent and effluent concentrations.

## **12.2    Introduction to the Full Report**

The user may access the introduction to the report by clicking on the *View Section 1* button. This introduction summarizes the farm and briefly describes the manure system. The introduction also describes a description for the other sections of the report: Section 2.0 User Inputs, Section 3.0 Technical Feasibility, Section 4.0 Economic Feasibility, Section 5.0 Environmental Performance, and Section 6.0 Warnings.

## **12.3    User Inputs**

Section 2.0, User Inputs, presents the user the opportunity to review user input. It is important for the user to check the accuracy of this information to insure the accuracy of the assessment. Section 2.0 includes four tables:

### **Table 2-1      Summary of General Information Provided by the User**

The table lists the farm's name, city (if entered), state, and the type of farm. The table also provides a list of the confinement facilities and manure collection system. It summarizes the current waste management system at the planned or existing farm and the proposed biogas recovery modifications.

### **Table 2-2:      Standing Animal Populations and Time Spent in Housing**

This table lists the types of the animals on the farm, the number of animals, and the hours per day spent in each of the housing facilities.

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### **Table 2-3:      Record of Energy Use in the Most Recent 12 Months**

The table shows the amount of energy used and the cost by electricity, fuel oil, and propane for the last 12 months. Electricity cost excludes demand and fixed charges.

### **Table 2-4:      Estimates of Water Use and Waste Flow through Housing**

The table displays the type of housing on the farm and the amount of fresh water and recycled water is used per day. In the last column, it also shows the amount of manure that is generated per day.

## **12.4      Technical Feasibility**

Based on the user inputs summarized in Section 2.0 of the report, Section 3.0 presents the monthly estimates for biogas methane produced, the amount of electricity that can be generated from the biogas, and the amount of fuel that can be saved. There are four tables in Section 3.0.

### **Table 3-1:      Monthly Estimates of Biogas, Methane, and BTU Production Potential**

Table 3-1 Monthly Estimates of Biogas, Methane, and BTU Production Potential lists the amount of biogas that FarmWare estimates will be produced.

### **Table 3-2:      Design Parameters**

This table lists all of the assumptions that FarmWare is using to generate the numbers listed in Table 3-1 Monthly Estimates of Biogas, Methane, and BTU Production Potential. Because every farm is different, each will have a different system plan and the assumptions will vary. But generally, the table will have the type of biogas production system, the total amount of waste generated and details about where the waste is stored (i.e. volume, retention time, and surface area).

### **Table 3-3:      Monthly Estimates of the Potential of Using Biogas**

This table will also vary depending on what selection was made on the **Energy Consumption** tab. The table will only list what the user selected: electricity, fuel oil, propane, or a combination of electricity and either fuel oil or propane (if cogeneration was chosen).

### **Table 3-4:      Energy Balance**

The fourth table is Table 3-4 Energy Balance. This table depends on the user's selection for the type of utility contract on the **Costs & Revenues** tab. The choices were net metering, sell all/buy all, and surplus sales. The table will always display the historical data by month, and the electricity that can be generated from the biogas. If "net metering" was chosen it will also have a column that shows the net difference between the historical use and the electricity generated from the biogas. If "sell all/buy all" was chosen, it will have a column for the potential sale to the utility and a column that shows what would be required from the local utility. If "surplus sale" was chosen it again will have a column for potential sale to the utility and the required from the local utility.

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### 12.5    Economic Feasibility

This section of the report gives the user s brief overview of the economic feasibility of a biogas recovery system. There are four tables in Section 4.0: Table 4-1 Financial Factors, Table 4-2 Equipment Capital Costs, Table 4-3 Operating and Maintenance Costs, and Table 4-4 Estimate of Energy Expense Saved through Biogas Use. The data in tables 4-1 through 4-3 are used by FarmWare to generate the numbers in table 4-4.

#### **Table 4-1:    Financial Factors**

The first table is Table 4-1 Financial Factors lists all of the factors that the user can view on the **Assessment** tab by clicking the *View/Edit Financial Factors* button. The Factors include: project lifetime, down payment percentage, loan interest rate, loan term, project discount rate, marginal tax rate, depreciation method, and general annual inflation rate.

If the user would only like to look at this table, the user can select anywhere on the table and it will bring up another tab called Table 4-1.rpt. The user can now easily scroll between the report and the various tables by clicking on the tabs.

#### **Table 4-2:    Capital Costs**

The second table is Table 4-2 Capital Costs. The table lists the various components of the facility including some design details, and the total capital cost. If the user would only like to look at this table, the user can select anywhere on the table and it will bring up another tab called table4-2.rpt. The user can now easily scroll between the report and the various tables by clicking on the tabs.

#### **Table 4-3:    Operating and Maintenance Costs**

The third table is Table 4-3 Operating and Maintenance Costs, and is similar to the previous table. This table again lists the various components of the facility and the operating and maintenance costs associated with each part of the facility.

#### **Table 4-4:    Estimate of Net Income from Biogas Production**

The fourth table is Table 4-4, Estimate of Energy Expense Saved through Biogas Use. This table is broken up by months and with five columns. The first column is the future energy cost, based on the user's current estimated use and implementation of the selected energy recovery system. The second column is the value of the energy derived from the biogas that used onsite. The third column is value of energy derived from biogas, delivered to the local electric utility. The fourth column is the cost associated with generating energy derived from biogas. The final column is the estimated net income derived from the biogas produced.

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### 12.6 Environmental Performance

This section contains one table, Table 5-1 Environmental Performance Comparison. The table lists the various components of the conventional system and the biogas recovery system along with air quality and water quality parameters associated with those components. This table presents quantitative estimates of methane generation from conventional and digester systems for comparison. Additionally, the table presents qualitative estimates of reductions in hydrogen sulfide, odor control, ammonia, COD, nitrogen, phosphorus, and pathogens.

Environmental performance data used in FarmWare is estimated from the following reports summarizing the performance of biogas recovery at dairy and swine farms:

- Barhams Study: Martin, J.H., Jr. 2002. A Comparison of the Performance of Three Swine Waste Stabilization Systems. Final report submitted to the U.S. Environmental Protection Agency AgSTAR Program by the Eastern Research Group, Inc., Boston, MA.
- Colorado Pork: Martin, J.H., Jr. 2003. An Assessment of the Performance of the Colorado Pork, LLC, Anaerobic Digestion and Biogas Utilization System. Final report submitted to the U.S. Environmental Protection Agency AgSTAR Program by the Eastern Research Group, Inc., Boston, MA.
- AA Dairy Study: Martin, J.H., Jr. 2004. A Comparison of Dairy Cattle Manure Management With and Without Anaerobic Digestion and Biogas Utilization. Final report submitted to the U.S. Environmental Protection Agency AgSTAR Program by the Eastern Research Group, Inc., Boston, MA.
- Deep Pit Study: Martin, J.H., Jr. 2003. A Characterization of Transformations Occurring as Swine Manure Accumulates in Deep Pits. Final report submitted to the U.S. Environmental Protection Agency AgSTAR Program by the Eastern Research Group, Inc., Boston, MA.

### 12.7 Warnings

The final section of the report lists various warnings that FarmWare previously indicated to the user and were not corrected. There are seven possible warnings that FarmWare tracks:

- Caution: A covered lagoon digester in this climate region may not effectively produce enough methane for energy recovery. You may choose another type of digestion on this page or select a methane use other than electricity generation in the Methane Utilization subscreen.
- Plug flow digestion requires at least weekly scraping for open lot manure to be viable waste for the digester.
- If your entire operation is 'All-In/ All-Out', then your revenues using digestion with methane recovery will be decreased from the analysis shown in FarmWare, because FarmWare assumes a

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constant standing population of animals. Your operation may not be ideal for digestion given the variability in manure availability if period between production cycles are excessively long.

- Caution: The process water and manure distribution inputs you have entered for this farm results in a hydraulic retention time (HRT) less than is recommended in this geographic region.
- Caution: The process water you have entered for this farm results in a hydraulic retention time (HRT) that is more than twice what is needed in this geographic region.
- The total solids entering the digester is {a} %. The digester system chosen operates ideally at {b}% to {c}% total solids. You may want to return to Farm Setup and change your inputs to improve the performance of your system.

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### CHAPTER 13.0: ACRONYMS

This section contains a list of acronyms frequently used in this Guide. Additional information may be available in section 14.0 Glossary.

BTU: British Thermal Units

COD: Chemical Oxygen Demand

CTSL: Combined Treatment and Storage Lagoons

DDB: Double Declining Balance

GPD: Gallons Per Day

HRT: Hydraulic Retention Time

kW: Kilowatt

kWh: Kilowatt Hour

LPG: Liquefied Petroleum Gas

MACRS: Modified Accelerated Cost Recovery System

MCL: Multiple Celled Lagoon

MOU: Memorandum of Understanding

NPV: Net Present Value

O & M: Operating and Maintenance

SYD: Sum of Years' Digits

TS: Total Solids

WMS: Waste Management System

VS: Total volatile solids

Bo: Maximum methane producing capacity

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### CHAPTER 14.0: DEFINITIONS

25 Year, 24 Hour Storm Event:	The rainfall event with a probable recurrence interval of once in 25 years with a duration of 24 hours, as defined by the National Weather Service in technical Paper Number 40, "Rainfall Frequency Atlas of the United States", May 1961, and subsequent amendments.
AgSTAR:	A voluntary federal program that encourages the use of effective technologies to capture methane gas, generated from the decomposition of animal manure, for use as an energy resource.
Anaerobic:	Requiring, or not destroyed by, the absence of air or free oxygen.
Anaerobic Bacteria:	Bacteria that only grow in the absence of free elemental oxygen.
Anaerobic Lagoon:	A treatment or stabilization process that involves retention under anaerobic conditions.
Anaerobic Digester:	A tank or other vessel for the decomposition of organic matter in the absence of elemental oxygen.
Anaerobic Digestion:	The degradation of organic matter including manure brought about through the action of microorganisms in the absence of elemental oxygen.
Bacteria:	A group of universally distributed and essentially unicellular microscopic organisms lacking chlorophyll.
Barn:	A totally or partially enclosed structure where animals are confined.
Conventional System	The existing or planned farm that does not have a biogas recovery system in place.
Best Management Practice (BMP):	A practice or combination of practices found to be the most effective, practicable (including economic and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.
Biogas:	Gas resulting from the decomposition of organic matter under anaerobic conditions. The principal constituents are methane and carbon dioxide.
Biogas Recovery System	A series of additional components and equipment that allow a farm to capture and use biogas from their waste stream for energy.
Biomass:	Plant materials and animal wastes used especially as a source of fuel.
British Thermal Unit (BTU):	The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One cubic foot of biogas typically contains about 600 to 800 BTUs of heat energy. By comparison, one cubic foot of natural gas contains about 1,000 BTUs.
Calf:	An immature dairy or beef animal up to approximately six months of age.
Chemical Oxygen Demand (COD):	COD is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For a sample from a specific source, COD can be related empirically to biochemical oxygen demand (BOD), organic carbon, or organic matter. (Note-This is the Standard Methods definition.)
Complete Mix Digester:	A controlled temperature, constant volume, mechanically, hydraulically, or gas mixed vessel designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.

Composting:	The biological decomposition and stabilization of organic matter under conditions, which allow the development of elevated temperatures as the result of biologically produced heat. When complete, the final product is sufficiently stable for storage and application to land without significant release of noxious odors.
Covered Lagoon Digester:	An anaerobic lagoon fitted with a gas impermeable cover designed to capture biogas resulting from the decomposition of manure.
Cow:	A mature female dairy or beef animal that has produced at least one calf.
Cow, Dry:	A mature cow in the period between the cessation of lactation and calving.
Cow, Lactating:	A lactating dairy or beef cow.
Dairy-Open Lot:	A dairy farm where cows are confined and fed in an open lot, also called a corral or paddock in some regions.
DDB Depreciation:	Double declining balance (DDB) depreciation is an accelerated depreciation method in which first year depreciation is double the amount of straight-line depreciation.
Demand charge:	The peak kW demand during any quarter hour interval multiplied by the demand charge rate.
Digester:	A concrete vessel used for the biological, physical, or chemical breakdown of livestock and poultry manure.
Discount rate:	The interest rate used to convert future payments into present values.
Down payment:	The investment made by the owner in a project.
Effluent:	The discharge from an anaerobic digester or other manure stabilization process. ?????
Energy Charge:	The energy charge rate times the total kWh of electricity used.
FarmWare:	AgSTAR decision support software that allows the evaluation of the costs and benefits of methane recovery systems.
Fecal coliforms:	Bacteria usually present in the feces and intestinal tracts of warm-blooded animals that ferment lactose to produce acid and gas. These can enter water bodies from human and animal waste.
Fecal streptococcus	Bacteria usually present in the feces and intestinal tracts of warm-blooded animals. These can enter water bodies from human and animal waste.
Feed Apron:	A paved or hard surface along one side of a open lot where feed is provided to the animals.
Feeder Pig:	A pig from about 60 pounds to market weight.
Finisher:	A swine animal finished for market.
Flushing System:	A manure collection system that collects and transports manure using water.
Freeboard:	The distance between the highest possible wastewater level in a manure storage/treatment structure and the top of the structure. Freeboard is an important design parameter in designing lagoons, ponds, storage basins, digesters, and other manure storage and treatment structures to avoid uncontrolled waste discharges.
Gilt:	A female swine that has not produced a litter of pigs. .
Greenhouse Gas:	An atmospheric gas, which is transparent to incoming solar radiation but absorbs the infrared radiation emitted by the Earth's surface. The principal greenhouse gases are carbon dioxide, methane, and CFCs.
Grower:	An immature male or female pig managed between weaning and finishing weights.

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Heifer:	A female dairy or beef animal that has not produced a calf.
Hydraulic Retention Time (HRT):	The average time required to displace the contents of a tank or lagoon at a given rate of effluent discharge (volume divided by rate of discharge). The HRT is an important design parameter for treatment lagoons, covered lagoon digesters, complete mix digesters, and plug flow digesters.
Inflation Rate:	The annual rate of increase in costs or sales prices in percent.
Influent:	The flow into an anaerobic digester or other manure stabilization process.
Internal Rate of Return (IRR):	The discount rate that makes the NPV of an income stream equal to zero.
Kilowatt (kW):	One thousand watts (1.341 horsepower).
Kilowatt Hour (kWh):	A unit of work or energy equal to that expended by one kilowatt in one hour or to 3.6 million joules. A unit of work or energy equal to that expended by one kilowatt in one hour (1.341 horsepower-hours).
Lagoon:	Any large holding or detention pond, usually with earthen dikes, used to contain wastewater while sedimentation and biological treatment or stabilization occurs.
Land Application:	Application of manure to land for reuse of the nutrients and organic matter for their fertilizer value.
Liquid Manure:	Manure having a total solids content of no more than five percent on a wet weight basis.
Organic Loading Rate:	The rate of volatile solids (VS) entering a manure management structure for biological stabilization. Loading rate often is expressed as pounds of VS/1000 cubic feet.
Loan Rate:	The interest rate on borrowed capital.
MACRS	Modified Accelerated Cost Recovery System. A depreciation method that may be applied in FarmWare over 7 or 10 years.
Manure:	The fecal and urinary excretions of livestock and poultry.
Marginal Tax Rate:	The percent of the methane recovery project net income to be paid in taxes.
Memorandum of Understanding (MOU):	An agreement between AgSTAR Partners, Allies, and Endorsers and the EPA stating the responsibilities and commitments agreed to by both parties.
Mesophilic:	Operationally between 80°F and 100°F (27°C and 38°C).
Methane:	A colorless, odorless, flammable gaseous hydrocarbon that is produced during the anaerobic decomposition of organic mater. Methane is a major greenhouse gas. Methane is also the principal component of natural gas.
Methane Project Lifetime:	The useful life of the structural components of the project.
Methane Recovery Lagoon:	See covered lagoon digester.
Minimum Treatment Volume:	The minimum volume necessary for the design HRT or loading rate.
Mix Tank:	A control point where manure is collected and added to water or dry manure to achieve the required solids content for a complete mix or plug flow digester.
Natural Gas:	A combustible mixture of hydrocarbons containing primarily used chiefly as a fuel.
Net Present Value (NPV):	The present value of all cash inflows and outflows of a project at a given discount rate over the life of the project.
Nonpoint Source Pollution:	Pollution resulting from intermittent discharges of pollutants from diffuse sources and transported over land before entering a water body.

NPV Payback:	The number of years it takes to pay back the capital cost of a project calculated with discounted future revenues and costs. Profitable projects will have an NPV Payback value less than or equal to the lifetime of the project.
Nursery:	A facility used to house and feed pigs between weaning and the grow/finish phase of swine production.
Nursery Pig:	A weaned pig up to about 60 pounds live weight.
Nutrients:	A substance required for plant or animal growth. The primary nutrients required by plants are nitrogen, phosphorus, and potassium. The primary nutrients required by animals are carbohydrates, fats, and proteins.
Operating Volume:	The volume of the lagoon needed to hold and treat the influent manure and accumulated precipitation.
Milking Center:	A facility where lactating cows are assembled and milked and the milk produced is stored
AgSTAR Partner:	A livestock producer who signs a Memorandum of Understanding (MOU) with the U.S. EPA and agrees to survey his/her facility and install methane recovery systems where profitable within 3 years.
Pasture:	An open area where the animals may roam freely and satisfy at least a substantial portion of their nutrient needs through grazing.
Payback Years:	The number of years it takes to pay back the capital cost of a project.
pH:	A measure of acidity or alkalinity. The pH scale ranges from zero to 14, with a value of 7 considered neutral. The lower a value, the higher the acidity, and the higher the value, the higher the alkalinity.
Piglet:	A nursing pig.
Plug Flow Digester:	A constant volume, flow-through, controlled temperature biological treatment unit designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.
Point Source Pollution:	Pollution entering surface waters from a discrete conveyance such as a pipe or ditch.
Process Water:	Water used in the normal operation of a livestock farm. Process water includes all sources of water that may need to be managed in the farm's manure management system.
Psychrophilic:	Operationally between 54°F and 64°F (12°C and 18°C).
Pull Plug Pit:	A series of one or more pits where manure is collected until transferred to a storage or treatment structure.
Scrape System:	Collection method that uses a mechanical device to regularly remove manure from barns, drylots, or other similar areas where manure is deposited.
Separator:	A mechanical device or gravity settling basin that separates manure into solid and liquid fractions.
Settling Basin:	A basin designed to remove solids by gravitational settling.
Sideslope:	The slope of a lagoon embankment, often expressed as the ratio of the horizontal displacement and vertical displacement.
Simple Payback:	The number of years it takes to pay back the capital cost of a project calculated without discounting future revenues or costs.

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# Appendix C      FarmWare User's Manual

## Version 3.0

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Sludge Volume:	Volume to allow for sludge accumulation in a manure storage or treatment structure. Sludge volume is an important design parameter for manure storage and treatment structures.
Slurry (Semi-solid) Manure:	Manure having a total solids content between five and ten percent.
Solids Manure:	Manure having a total solids content exceeding 10 percent.
Sow:	A female pig that has produced at least one litter of piglets.
Storage Pond:	An earthen basin designed to store manure and wastewater until it can be utilized. Storage ponds are not designed to treat manure.
Storage Tank:	A concrete or metal tank designed to store manure and wastewater until it can be utilized. Storage tanks are not designed to treat manure.
Storm Water Runoff:	Manure contaminated rainfall which must be stored and utilized on the farm and may not be discharged into rivers, streams, lakes, or other bodies of water.
Straight-Line Depreciation:	Depreciation per year equals the total facility cost divided by the years of depreciation (usually the facility lifetime).
Supplemental Heat:	Heat added to complete mix and plug-flow digesters to maintain a constant operating temperature.
Swine-Farrow-to-Finish:	A swine operation where pigs are raised from birth to market weight.
Swine-Farrow-to-Nursery:	A swine operation where pigs are raised from birth to weaning.
Swine-Farrow-to-Feeder:	A swine operation where pigs are raised from birth to approximately 60 pounds live weight.
Swine-Grow/Finish:	A swine operation where feeder pigs are fed to market weight.
SYD Depreciation:	Sum of Years' Digits (SYD) is a common accelerated depreciation method where the sum of the digits is the total of the numbers representing the years of depreciation (usually the facility lifetime).
Thermophilic:	Operationally between 110°F and 140°F (43°C and 60°C).
Total Solids:	The sum of dissolved and suspended solids usually expressed as a concentration or percentage on a wet basis.
Utility Interconnection:	The method of utilizing electricity produced from manure management facilities. Options include: Sell all/Buy all, Surplus Sale, or Net Metering
Volatile Solids:	The fraction of total solids that is comprised primarily of organic matter.
Volatilization:	The loss of a dissolved gas, such as ammonia, from solution.
Volumetric Loading Rate:	The influent or effluent flow rate per unit of system volume. Usually expressed as cubic feet per 1,000 cubic feet per day..

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# Appendix D      Reserved

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**Reserved for Future Use**

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**To be inserted later**

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# Appendix F      National Resource Conservation Service Practice Standards

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Each state determines which national conservation practice standards are applicable in their state. States often add technical criteria and issue them as state conservation practice standards. You should consult with the state to ensure that you meet all state and local standards, which may be more restrictive than national standards. To find your state office or review these practice standards on line, please visit [www.nrcs.usda.gov](http://www.nrcs.usda.gov).

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# Appendix F      National Resource Conservation Service Practice Standards

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## ANAEROBIC DIGESTER – AMBIENT TEMPERATURE

(No.)

Code 365

### DEFINITION

An unheated waste treatment impoundment.

### PURPOSE

To biologically treat waste as a component of a waste management system to:

- produce biogas and capture for energy
- improve air quality
- reduce greenhouse gas emissions

### CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Biogas production and capture are components of a planned animal waste management system. Suitable geographic areas for energy recovery are shown in Figure F-1.
- Existing waste impoundment(s) can be modified to the requirements of this standard or for new construction.
- The digester is in conjunction with a separate waste storage facility or where the digester and storage are congruent.
- Manure can be collected fresh and delivered to the digester with a total solids (TS) concentration in the influent waste of less than 2 percent.
- The operator has the interest and training to monitor and maintain processes or contracts with a consultant to provide these services.

### CRITERIA

#### General Criteria Applicable to All Purposes

**Laws and Regulations.** Waste treatment facilities must be planned, designed, and constructed to meet all Federal, State, and local regulations.

**Manure Characteristics.** This practice is applicable to manure that is collected fresh, generally less than 7 days old. Manure shall be essentially free of soil, sand, stones, or fibrous bedding material (including clumps of straw), or processed to remove such material.

Ruminant's manure shall be treated with solid separation prior to entry into the digester.

**Rainfall Runoff.** Rainfall runoff shall be diverted away from the digester.

**Anaerobic Digester.** The digester shall meet the General Criteria for All Lagoons given in Practice Standard 359, Waste Treatment Lagoon, as appropriate, and the following additional requirements:

1. **Minimum Treatment (Design Operating) Volume.** The design operating volume shall be based either on the daily volatile solids (VS) loading rate per 1,000 ft<sup>3</sup> or the minimum hydraulic retention time (HRT) adequate for methane production, whichever is greater. The maximum daily VS loading rate shall be selected from the values listed on the map in Figure F-2. The minimum HRT shall be selected from values listed on the map in Figure F-3.
2. **Required Total Volume.** The required total volume of the digester shall be equal to the minimum treatment volume except where waste storage is included in the design, in which case the volume shall meet the additional criteria for Design Storage Volume in Practice Standard 313, Waste Storage Facility, as appropriate.

The digester storage volume does not need to account for rainfall except for partially covered digesters.

3. A minimum of 2 feet of freeboard above the digester design water surface shall be provided except when rainfall is included in determining the operating volume, where only 1 foot of freeboard is required.
4. Length to Width Ratio. The ratio of length to width of the digester is limited to 4:1 or less.
5. Operating Depth. The operating depth of the digester shall be at least 12 feet over 50 percent or more of the bottom area.
6. Interior Slopes. Interior slopes shall be as steep as permitted by soil properties and construction techniques.
7. Waste Inlet and Outlet. The inlet and outlet devices shall be located as far apart as practical to minimize “short circuiting.”
8. The inlet shall discharge a minimum of 12 inches below the digester water surface.
9. Outlet. The digester shall be equipped with an outflow device that maintains the digester water surface at its operating level. Except where the digester is designed to include storage, the outlet shall release directly to the waste storage facility without release of trapped gas.
10. Digester Cover. The digester cover, materials, anchorage, and all appurtenances, such as weights and floats, shall be designed to capture and convey biogas to the gas collection system. The digester cover and materials shall meet the requirements of Practice Standard 367, Waste Facility Cover.

**Separate Waste Storage Facility.** Separate waste storage facilities shall meet the requirements of Practice Standard 313, Waste Storage Facility. No storage credit shall be attributed to the digester in meeting the minimum storage requirements in Practice Standard 313 except for sludge volume reduction based on expected total solids (TS) removed or destroyed.

**Gas Collection, Transfer, and Control System.** The biogas collection, transfer, and control system

shall be designed to convey captured gas from under the digester cover to gas utilization equipment or device (flare, boiler, engine, etc.).

#### Gas Collection and Transfer

- 1) Perforated pipe and other components under the digester cover shall be designed to exclude floating debris and waste residue and shall have a service life consistent with the expected cover life, but not less than 10 years.
- 2) Pipe and components under the cover shall be securely anchored to prevent displacement from normal cover forces.
- 3) The collection and transfer pipe shall be designed for wet biogas. In colder climates, the pipe shall be protected as necessary to prevent frost buildup. In no case shall the pipe size be less than 3-inch diameter.
- 4) Pipe used for transfer of gas can be buried or installed above ground and must include provisions for drainage of condensate, pressure and vacuum relief, and flame traps.

#### Gas Control

- 1) Gas control equipment and components shall be conveniently located and sheltered from the elements. A minimum distance of 30 feet (10 m) shall separate the control facility from the digester.
- 2) Gas control equipment and components shall have a service life of not less than 2 years and shall be readily accessible for replacement or repair.
- 3) The size of equipment and connecting pipe shall be based on head loss, cost of energy, cost of components, and manufacturers’ recommendations.
- 4) Where electrical service is required at the control facility, the installation and all electrical wire, fixtures and equipment shall meet the National Electrical Code and local and state requirements.

**Gas Utilization.** Gas utilization equipment shall be designed and installed in accordance with standard engineering practice and the manufacturer

recommendations. As a minimum, the installation will include a flare to burn off collected gas.

1. The flare shall be equipped with automatic ignition and powered by battery/solar or direct connection to electrical service. The flare shall have a minimum capacity equal to the anticipated maximum biogas production.
2. Gas-fired boilers, turbines, and internal combustion engines, when a component of the system, shall be designed for burning biogas directly or shall include equipment for removing  $H_2S$  and other contaminants from the biogas.

**Monitoring.** When the purpose is to produce and capture biogas for energy, equipment needed to properly monitor the digester and gas production shall be installed as part of the system. As a minimum, the following equipment is required:

- A temperature sensor and readout device to measure internal temperature of digester.
- Gas meter suitable for measuring biogas.

**Safety.** Methane is a flammable gas. The gas collection, control, and utilization system shall be designed to incorporate measures to prevent undue safety hazards. As a minimum, “Warning Flammable Gas” and “No Smoking” signs shall be posted.

Flares shall be located a minimum distance of 95 feet (30 m) from the biogas source and grounded or otherwise protected to minimize the chance of lightning strikes.

A flame trap device shall be provided in the gas line between the digester and points of use (flare, boiler, engine, etc.).

The location of underground gas pipe shall be marked with signs to prevent accidental disturbance or rupture. Mark exposed pipe to indicate whether gas line or other.

## **CONSIDERATIONS**

**Location.** In determining the location of the waste storage facility, consider elevation and distance

from the covered digester to take advantage of gravity flow.

The covered digester should be located as near the source of manure as practicable and as far from neighboring dwellings or public areas (minimum distance of 300 ft (100 m)) as possible. Proper location should consider slope, distance of manure transmission, vehicle access, wind direction, neighboring dwellings, proximity of streams and flood plains, and visibility.

Using available gas to heat the digester can improve total solids destruction and further reduce greenhouse gas emissions. In geographic areas north of the 40th parallel (Figure F-1), heat is required to maintain year around anaerobic digestion.

The covered digester should be located near a suitable site for energy utilization equipment. Short distances for the transmission of methane through buried pipe are preferable.

**Waste Transfer Pipe.** The standard practice is to locate a cleanout immediately upstream of the digester. Influent from the waste collection pit discharges below the digester operating level, and depending on the installation, solids tend to build up in the inlet pipe. The cleanout is also a good location for venting any gas that builds up in the transfer pipe.

**Visual Screening.** Analyze the visual impact of the digester within the overall landscape context or viewshed. Screening with vegetative plantings, landforms, or other measures may be implemented to alleviate a negative impact or enhance the view.

**Depth of Digester.** Improved digester performance and reduced cover cost (less area for given volume) can be realized with deeper digesters.

**Rainfall.** Rainfall on the digester cover can result in increased effluent discharge into the storage facility. For normal rainfall events this is probably not a problem. In locations subject to high rainfall events (thunderstorms and hurricanes), a ported riser on the outflow pipe should be considered to provide temporary storage and reduce outflow rate.

**Gas Transfer Pipe.** Exposed pipe conveying flammable gas is generally painted orange.

### **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and good engineering practice. The plans and specifications shall include all details necessary for construction and completion of the work.

As a minimum, the plans and specifications shall provide the following:

1. Layout of livestock facilities, waste collection points, waste transfer pipe, digester, and storage pond.
2. Location of all digester influent pipes and devices.
3. Details of pipe material, size, and grade.
4. All digester and storage pond dimensions, type of lining material, and other parameters as appropriate.
5. Digester cover material and dimensions of covered surface. Means of rainfall removal or details of drainage.
6. Details of digester cover anchorage (ex: location and width of trench, depth, backfill material, and compaction of fill).
7. Details of the gas collection system, including type of pipe, devices, sizes, location, material, and grades.
8. Details of gas control facility, piping layout, components, electrical service if required, and protection from the elements.
9. Appropriate gas safety equipment or protective measures.

**Warranties.** The cover manufacturer and/or installer shall warrant the cover for the intended use and design life, provide maintenance instructions, and certify that the cover is properly installed.

### **OPERATION AND MAINTENANCE**

An operation and maintenance (O&M) plan shall be developed and reviewed with the owner prior to construction. The O&M plan shall be consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The plan shall list operation and maintenance requirements including but not limited to:

1. Proper loading rate of the digester and total solids content of influent.
2. Proper operating level of the digester.
3. Estimates of biogas production, methane content, and potential energy recovery.
4. A description of the planned startup procedures, normal operation, safety issues, and normal maintenance items.
5. Alternative operation procedures in the event of equipment failure.
6. Instructions for safe use and/or flaring of biogas.
7. Cover and gas collection system maintenance.
8. Daily inspection of the following:
  - Cover material – check for cracks, tears, or points of distress around perimeter.
  - Check for excessive ballooning of cover or presence of odor.
  - Check for excess rainwater on cover.
  - Check gas control panel, regulators, pressure gages, electrical power, flowmeter, flare igniter, and flare operation.
9. Frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate.

# Appendix F National Resource Conservation Service Practice Standards

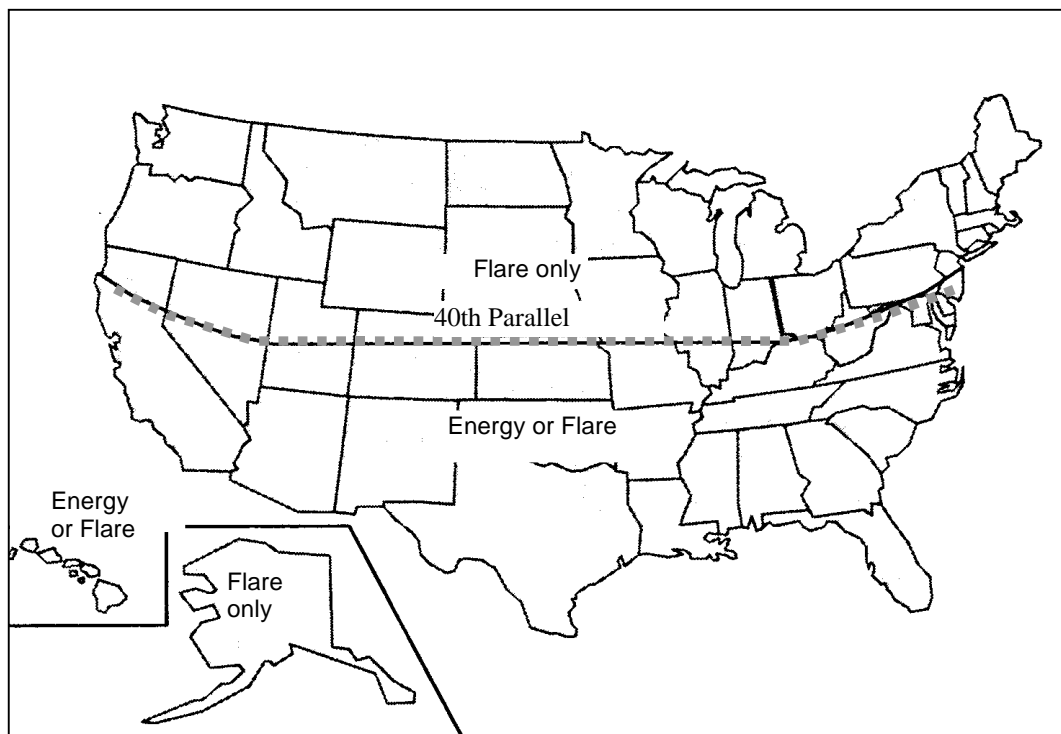


Figure F-1. Locations suitable for energy production with an ambient temperature digester generally fall below the 40th parallel.

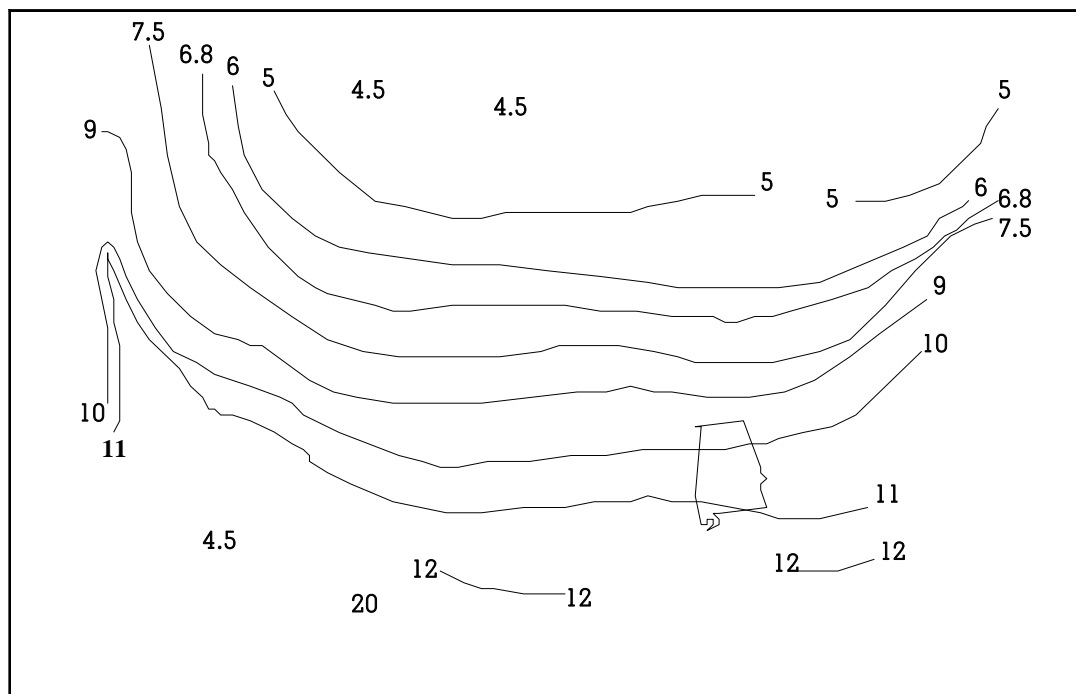


Figure F-2. Covered anaerobic digester maximum loading rate (lb VS/1,000 ft³/day)

F-2.

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## Appendix F      National Resource Conservation Service Practice Standards

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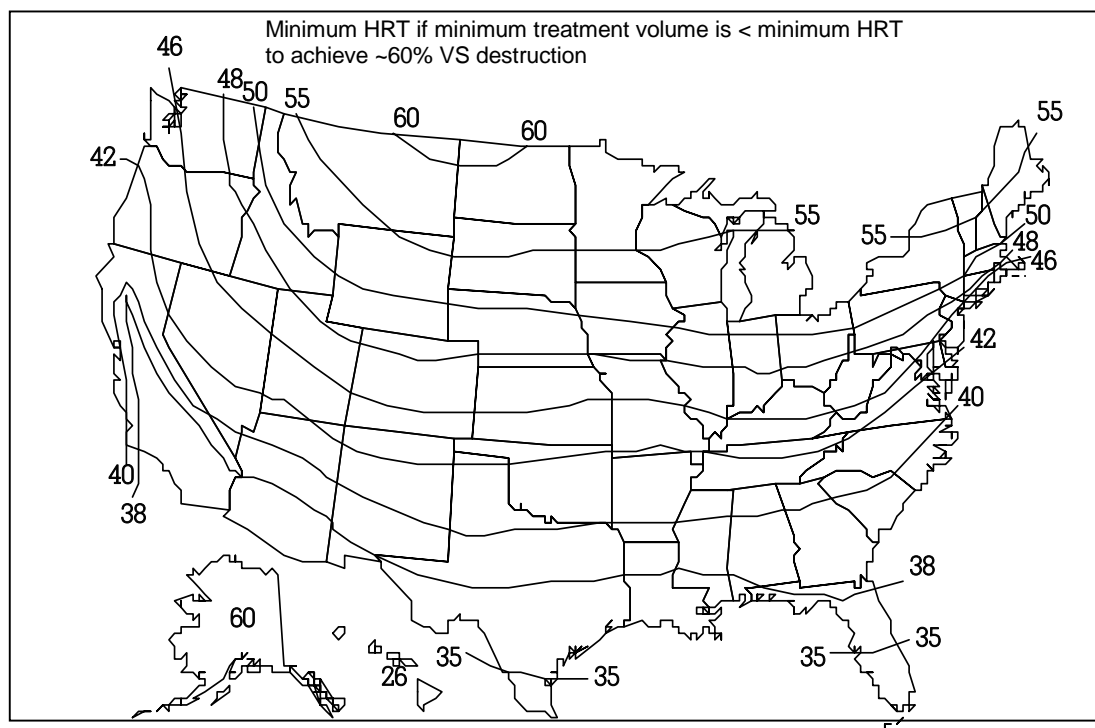


Figure F-3. Covered anaerobic digester minimum hydraulic retention times (MINHRT) in days

**ANAEROBIC DIGESTER –  
CONTROLLED TEMPERATURE**

(No.)

**Code 366****DEFINITION**

A managed temperature waste treatment facility.

**PURPOSE**

To biologically treat waste as a component of a waste management system to:

- produce biogas and capture for energy
- improve air quality
- reduce greenhouse gas emissions
- reduce pathogens
- improve nutrient management

**CONDITIONS WHERE PRACTICE  
APPLIES**

This practice applies where:

- Biogas production and capture are components of a planned animal waste management system.
- Existing facilities can be modified to the requirements of this standard or for new construction.
- Manure can be collected fresh and delivered to the digester with a total solids (TS) concentration up to 14 percent.
- The operator has the interest and training to monitor and maintain processes or contracts with a consultant to provide these services.

**CRITERIA****General Criteria Applicable to All Purposes**

**Laws and Regulations.** Waste treatment facilities must be planned, designed, and constructed to meet all Federal, State, and local regulations.

**Manure Characteristics.** This practice is applicable to manure that is collected fresh, generally less than 7 days old. Manure shall be essentially free of soil, sand, stones, or fibrous bedding material (including clumps of straw), or otherwise processed to remove or reduce such material.

**Total Solids Concentration.** The total solids of manure influent to the digester shall be as required by the digester type and process design. Except for any supplemental feedstocks and non-manure wastewater as described in following sections, water or wastewater, other than that needed for dilution to achieve the design total solids concentration, shall be excluded from the digester.

**Treatment of Supplemental Feedstocks.** Food waste and wastewater from food processing operations may be added as supplemental feedstocks to a digester when the following conditions are satisfied:

1. The digester is designed to treat such wastes, as documented in the Plans and Specifications.
2. The digester Operation and Maintenance Plan includes the handling and treatment of such wastes.
3. The farm's nutrient management plan accounts for the nutrient impact of such wastes.
4. The treatment of such wastes meets with all State and local regulations.

**Treatment of Non-manure Wastewater.**

Wastewater from farm operations, such as milking parlor wastewater, barn floor wash water, and runoff from silage bunkers, may be added to a digester when the following conditions are satisfied:

1. The digester design has accounted for the use and treatment of such wastewater and included appropriate handling of such wastewater in the operation and maintenance plan.

2. The farm's nutrient management plan accounts for the nutrient impact of such wastewater.

**Safety.** If the digester will create a safety hazard, it shall be fenced and warning signs posted to prevent children and others from using it for purposes other than intended.

The effect of earthquake loads on the digester and biogas system shall be considered and appropriate protective measures incorporated into the design.

Biogas is flammable and highly toxic. The design of the digester and gas components must consider the hazards associated with normal operation and maintenance and provide adequate safety measures.

**Digester Design.** Digesters shall be designed to facilitate anaerobic digestion of animal manure and meet the minimum design and operational requirements below for the type of digester specified. The design documentation shall specify the type of digester and include a process diagram with the following minimum information:

1. Flow rates, influent, and effluent
2. Design total and volatile solids content of influent and effluent
3. Digester volume
4. Retention time
5. Heating system, control, and monitoring
6. Methane yield
7. 12-month energy budget when applicable
8. Process control and monitoring

### **Digester Types**

#### Plug Flow Digester

- For ruminant manure the total solids concentration of influent shall be 11 to 14 percent. For other manure sources the total solids concentration shall be 8 to 14 percent.
- Digester retention time shall be  $\geq 20$  days.
- Operational temperature shall be mesophilic (35 °C to 40 °C).
- The length to width ratio of digester flow path shall be between 3.5:1 and 5:1.

- The ratio of flow path width to fluid depth shall be less than 2.5:1.
- The shape of the floor and walls shall be uniform to minimize mixing.

#### Complete Mix Digester

- Total solids concentration of manure influent shall be from 2.5 to 10 percent.
- Digester retention time shall be  $\geq 17$  days.
- Operational temperature shall be mesophilic (35 °C to 40 °C).
- Appropriate mixing devices shall be provided to assure a complete mix process.

#### Fixed Film Digester

- Total solids concentration of influent shall be  $\leq 5$  percent. For total solids concentration  $\geq 2.5$  percent, the influent particle size shall be  $\leq 0.25$  inch.
- Digester retention time shall range from 1 to 6 days, depending on waste biodegradability.
- Operational temperature shall range from 15 °C (59 °F) to 40 °C (103 °F).
- Microbial support material with  $\geq 3$  inch openings

### **Alternative Digester Design Criteria**

Design of digesters not meeting the listed design and operational criteria or for a type other than listed in this standard shall be based on the documented design and performance of such existing animal waste digester and certified as such by a registered professional engineer licensed in the state of the proposed installation.

**Digester Vessel Characteristics.** The digester vessel (tank) shall be a corrosion-protected material or concrete structure, above or below ground, with allowances for entry and exit of manure, heat pipes, and/or other appurtenances. The tank shall be equipped with a suitable cover designed for accumulation and collection of biogas. The tank and internal components shall be designed to facilitate periodic removal of accumulated solids.

Digester vessels shall meet the structural criteria for “Fabricated Structures” in Practice Standard (313), Waste Storage Facility, and the requirements of state and local seismic codes as applicable.

The following additional criteria apply:

1. **Design Operating Volume.** The digester shall be sized to retain the volume of manure and water at the design total solids concentration for the digester design retention time (days).
2. **Configuration.** The configuration of the digester tank is specific to the type of digester design and may be square, rectangular, circular, or as necessary to most effectively meet specific criteria listed under Digester Design. Tank dividers or flow separators can be utilized to increase efficiency.
3. **Location of Inlet and Outlet.** The inlet and outlet devices shall be located to facilitate process flow.
4. **Inlet.** Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage, and prevent gas loss.
5. **Outlet.** The digester shall be equipped with an outflow device, such as an underflow weir, that will maintain the operating level, maintain a gas seal under the cover, prevent gas loss, and release effluent directly to separation, storage, or other treatment facility.
6. **Cover.** The digester cover shall be designed for all internal and external loads and shall capture and convey the biogas to a designed gas outlet. The cover system shall be designed to exclude the entrance of air under all operating conditions. Where the cover is exposed to the weather, the design shall account for environmental conditions for its service life. Precipitation runoff shall be collected and discharged to suitable grassed or otherwise stabilized areas.

Covers shall meet the requirements of Practice Standard (367), Waste Facility Cover.

### **Operating Temperature.**

Digesters shall be maintained at internal temperatures appropriate to the digester type and

design. The design shall include heat loss calculations to determine insulation, heat exchanger capacity, and energy requirements as appropriate for maintaining the digester operating temperature within acceptable limits.

**Mesophilic Digesters** - The digester shall be maintained between 35 °C and 40 °C (95 °F-103 °F) with an optimum of 37.5 °C (100 °F) and daily fluctuation of digester temperature limited to less than 0.55 °C (1 °F).

**Operating Level.** The operating level of digesters shall be designed with appropriate freeboard and overflow or automatic shutdown devices to prevent accidental spillage of effluent or discharge into the gas collection system.

### **Gas Collection, Transfer, and Control System.**

The biogas collection, transfer, and control system shall be designed to convey captured gas from within the digester to gas utilization equipment or devices (flare, boiler, engine, etc.).

1. **Gas collection and transfer** - Pipe and/or appurtenances shall meet the following:
  - The gas collection system within the digester shall be designed to facilitate exclusion of floating debris.
  - Pipe and components within the digester shall be securely anchored to prevent displacement from normal forces including loads from accumulated scum.
  - Pipe shall be designed for wet biogas. In colder climates, the pipe may need to be insulated to prevent frost buildup.
  - Pipes shall be constructed to enable all sections to be safely isolated and cleaned as part of routine maintenance.
  - Transfer pipe can be buried or installed above ground and must include provisions for drainage of condensate.
2. **Gas Control**
  - Equipment and components shall be conveniently located and sheltered from the elements.

- Equipment and components shall have a service life of not less than 2 years and shall be readily accessible for replacement or repair.
- The size of equipment and connecting pipe shall be based on head loss, cost of energy, cost of components, and manufacturers' recommendations.
- Gas pipe installed within buildings shall be of type approved for combustible gas.
- Where electrical service is required at the control facility, the installation and all electrical wire, fixtures, and equipment shall meet the National Electrical Code and local and state requirements.

**Gas Utilization.** Gas utilization equipment shall be designed and installed in accordance with standard engineering practice and the manufacturer's recommendations. As a minimum, the installation will include a flare to burn off collected gas and a means of maintaining the digester within acceptable operating temperature limits.

- The flare shall be equipped with automatic ignition and powered by battery/solar or direct connection to electrical service. The flare shall have a minimum capacity equal to the anticipated maximum biogas production.
- Gas-fired boilers, fuel cells, turbines, and internal combustion engines, when a component of the system, shall be designed for burning biogas directly, in a mix with other fuel, or shall include equipment for removing H<sub>2</sub>S and other contaminants from the biogas.

**Monitoring.** Equipment needed to properly monitor the digester and gas production shall be installed as part of the system. As a minimum the following equipment is required:

- Temperature sensors and readout device to measure internal temperature of digester
- Temperature sensors and readout device to measure inflow and outflow temperature of digester heat exchanger
- Gas meter suitable for measuring biogas

**Safety.** Biogas is a flammable gas. The gas collection, control, and utilization system shall be

designed in accordance with standard engineering practice for handling a flammable gas and to prevent undue safety hazards. As a minimum:

- “Warning Flammable Gas” and “No Smoking” signs shall be posted.
- Flares shall be grounded or otherwise protected to minimize the chance of lightening strikes.
- A flame trap device shall be provided in the gas line between the digester and sources of ignition or as recommended by the flame arrester manufacturer.
- The location of underground gas lines shall be marked with signs to prevent accidental disturbance or rupture. Mark exposed pipe to indicate whether gas line or other.

**Waste Storage Facility.** When a waste storage facility is a component of the waste system, it shall meet the requirements of Practice Standard, 313, Waste Storage Facility. The volume of the digester shall not be considered in determining the storage requirement of the waste storage facility except that the sludge volume can be reduced by the anticipated percent destruction of total solids.

## CONSIDERATIONS

**Location.** The digester should be located as near the source of manure as practicable and as far from neighboring dwellings or public areas (minimum distance of 91 m (300 ft)) as possible. Proper location should also consider slope, distance of manure transmission, vehicle access, wind direction, proximity of streams and flood plains, and visibility. The digester should be located near a suitable site for energy utilization equipment. Short distances for the transmission of biogas through buried pipe are preferable. In determining the location of the waste storage facility, consider elevation and distance from the digester to take advantage of gravity flow.

**Manure Characteristics.** Aged manure can be fed to the digester if properly reconstituted to the digester design total solids content. The biogas yield from aged manure (generally less than 6 months old) is dependent on the biodegradation that has taken place during the storage period. If frozen, little biodegradation will have occurred, whereas

manure in a warm, moist state could be significantly degraded.

**Collection/Mix Tank.** A collection/mix tank may be included to accumulate manure, settle foreign material, and pre-treat influent waste to the appropriate total solids concentration. A volume equal to 2 days of manure collection is recommended.

**Digester Design.** A digester operating fluid depth of 8 feet or greater is generally considered more economical for tank design.

**Gas Collection Cover.** In areas of extreme wind or excessive snow, appropriate structures may be necessary to protect inflatable and floating digester covers from damage.

**Cover Design.** A variety of digester cover designs can be considered to meet the needs of the farm. A secured, flexible membrane cover can be designed for significant storage of biogas whereas a rigid cover generally has limited storage.

**Gas Utilization.** The most beneficial use of the biogas energy must be investigated and selected. Depending on the design and climate, digesters may require up to 50 percent of the biogas heat value to maintain the design temperature in the winter. Digesters can be heated by hot water from boilers burning biogas or by heat recovery from engines burning biogas for power generation.

**Effluent Tank.** An effluent tank to hold digester effluent for solids separation treatment may be considered due to the potential value of digested separated solids for bedding or soil amendment.

**Visual Screening.** Analyze the visual impact of the digester within the overall landscape context or viewshed. Screening with vegetative plantings, landforms, or other measures may be implemented to alleviate a negative impact or enhance the view.

### PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and sound engineering practice, and shall describe the requirements for applying this practice to achieve its intended use.

As a minimum, the plans and specifications shall provide the following:

1. Layout and location of livestock facilities, waste collection points, waste transfer pipe, digester, biogas utilization facilities, and digester effluent storage.
2. Grading plan showing excavation, fill, and drainage, as appropriate.
3. Materials and structural details of the digester, including all premixing tanks, inlets, outlets, pipes, pumps, valves, and appurtenances as appropriate to the complete system.
4. Details of gas collection, control, and utilization system including type of materials for pipe, valves, regulators, pressure gages, electrical power and interface as appropriate, flowmeters, flare, utilization equipment, and associated appurtenances.
5. A process flow diagram.

### OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. The plan shall contain operation and maintenance requirements including but not limited to:

- Proper loading rate of the digester and total solids content of the influent.
- Proper operating procedures for the digester.
- Estimates of biogas production, methane content, and potential energy recovery.
- Description of the planned startup procedures, normal operation, safety issues, and normal maintenance items.
- Alternative operation procedures in the event of equipment failure.
- Instructions for safe use or flaring of biogas.
- Digester and other component maintenance.
- Troubleshooting guide.

Monitoring plan with frequency of measuring and recording digester inflow, operating temperatures, biogas yield, and/or other information as appropriate.

**WASTE FACILITY COVER**

(No.)

**CODE 367****DEFINITION**

A fabricated rigid, semi-rigid, or flexible membrane over a waste treatment or storage facility.

**PURPOSE**

To cover a waste facility for:

- water quality improvement
- air quality improvement
- capture of biogas for energy production

**CONDITIONS WHERE PRACTICE  
APPLIES**

This practice applies where:

- Exclusion of precipitation from an animal waste storage or treatment facility will improve management of an existing or planned system.
- Capture and controlled release or flaring of emissions from an existing or planned agricultural waste storage will improve air quality.
- Bio-treatment of emissions from an existing or planned waste storage or treatment facility will improve air quality
- Biogas production and capture for energy are components of an existing or planned animal waste system.

**CRITERIA*****General Criteria Applicable to All Purposes***

**Laws and Regulations.** Cover systems for animal waste facilities must be planned, designed, and constructed to meet all federal, state and local regulations.

**Service Life.** The cover and appurtenances shall be designed to provide a service life of not less than 10 years.

**Materials.** The type, thickness and material properties of the cover and any supporting members shall account for all loads and stresses due to operational, environmental, and climatic conditions.

Flexible membrane materials, used for fabrication of inflated and floating covers, shall be certified by the manufacturer as suitable for the intended application.

**Loads.** Where applicable, the membrane cover and support system shall be designed to resist snow and wind loads as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads.

**Biogas Emissions.** The cover system shall provide for capture and control of biogas, bio-reduction and direct release of gaseous emissions, or contain and release of gaseous emissions, as appropriate.

**Capture and Control**

The cover system shall be designed to capture biogas emissions and transfer to point of discharge without mixing with air. The point of discharge shall be equipped with a flare or utilization equipment as appropriate.

**Bio-reduction and Direct Release**

The cover shall be fabricated of a permeable composite membrane designed to promote biological treatment of gaseous emissions. Gaseous emissions pass through the membrane for direct release to the atmosphere.

**Contain and Release**

The cover system is designed for rainfall exclusion and not to specifically capture biogas. Therefore special handling or treatment of biogas emissions is not required except as necessary to prevent undue safety hazards.

**Anchorage.** The cover anchorage system shall be designed in a manner to resist internal gas pressures, corrosive environment, wind loads or other forces as appropriate to the cover system.

**Repair.** New and aged flexible cover materials shall be readily repairable by solvent, adhesive, or

thermoplastic welding. Semi-rigid cover material shall be repairable by sectional replacement.

**Precipitation.** Impermeable covers shall direct precipitation to collection points for removal by pumping or by controlled release to suitable grassed or otherwise stabilized areas for discharge.

**Access.** Covers shall be removable or otherwise provided with suitable equipment access as necessary for normal operation and maintenance of the waste facility.

**Safety.** The cover shall include safety features, including fences and warning signs as appropriate to prevent undue hazards.

As a minimum all covers shall include the following:

- “Warning Flammable Gas” and “No Smoking” signs shall be posted.

Where biogas is captured, the gas collection and control system shall be designed in accordance with standard engineering practice for safely handling a flammable gas.

Flares shall be grounded or otherwise protected to minimize the chance of lightning strikes.

A flame trap device shall be provided in the gas line between the flare and the waste facility.

The location of underground gas lines shall be marked with signs to prevent accidental disturbance or rupture.

### ***Additional Criteria for Rigid Covers***

Rigid covers shall meet the structural requirements of Practice Standard 313, Waste Storage Facility.

The cover or cover vessel design shall include provisions for fail safe pressure relief. Maximum pressure shall not exceed 12 inches water column.

### **Additional Criteria for Inflated Covers**

Covers inflated and supported by forced air from mechanical means shall be:

- Equipped with a warning system to notify operator of blower failure.
- Provided with a support system to limit cover collapse in the event the blower fails and for access of equipment.

- Provided with a suitable access port for normal maintenance equipment.

### **Additional Criteria for Floating Covers**

Floating membrane covers shall be supplemented with floatation materials as necessary for proper function, operation, and maintenance.

Minimum membrane or composite membrane thickness shall be 40 mils.

### ***Additional Criteria for Energy Production***

The cover materials and all appurtenances such as weights and floats shall be designed to capture and convey biogas to the gas collection system. The cover design shall provide for the following:

1. Air Infiltration. The cover system and appurtenances, including perimeter soil slopes above the water line for in-ground digesters, shall be designed to exclude the entrance of air under all operating conditions.
2. Material. The minimum material thickness for flexible geomembrane covers shall be:
  - 40 mils for non reinforced material
  - 36 mils for reinforced materials
3. Gas Collection, Control, and Utilization. The collection of biogas and flaring or other end use shall meet appropriate criteria in Practice Standard 365, Anaerobic Digester – Ambient Temperature.

## **CONSIDERATIONS**

Animal waste storage facilities can release large amounts of biogas at certain times of the year. The cover and gas collection system should be designed for release of this gas.

Storage of biogas should be considered when installing flexible covers over storage impoundments (lagoons) to attenuate gas supply for end use or controlled release.

## **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and

shall describe the requirements for applying the practice to achieve its intended use.

**OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria used for its design.

When gas storage is included in the system design, the plan shall contain instructions as to limits of cover ballooning and emergency procedures if control equipment fails.

**Warranties.** The cover manufacturer and or installer shall warrant the cover for the intended use and design life, provide maintenance instructions, and certify that the cover is properly installed.

**WASTE STORAGE FACILITY****(No.)****CODE 313****DEFINITION**

A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure.

**PURPOSE**

To temporarily store wastes such as manure, wastewater, and contaminated runoff as a storage function component of an agricultural waste management system.

**CONDITIONS WHERE PRACTICE APPLIES**

- Where the storage facility is a component of a planned agricultural waste management system
- Where temporary storage is needed for organic wastes generated by agricultural production or processing
- Where the storage facility can be constructed, operated and maintained without polluting air or water resources
- Where site conditions are suitable for construction of the facility
- To facilities utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads.
- To fabricated structures including tanks, stacking facilities, and pond appurtenances.

**CRITERIA****General Criteria Applicable to All Waste Storage Facilities.**

**Laws and Regulations.** Waste storage facilities must be planned, designed, and constructed to meet all federal, state, and local laws and regulations.

**Location.** To minimize the potential for contamination of streams, waste storage facilities should be located outside of floodplains. However, if site restrictions require location within a floodplain, they shall be protected from inundation or damage from a 25-year flood event, or larger if required by laws, rules, and regulations. Waste storage facilities shall be located so the potential impacts from breach of embankment, accidental release, and liner failure are minimized; and separation distances are such that prevailing winds and landscape elements such as building arrangement, landforms, and vegetation minimize odors and protect aesthetic values.

**Storage Period.** The storage period is the maximum length of time anticipated between emptying events. The minimum storage period shall be based on the timing required for environmentally safe waste utilization considering the climate, crops, soil, equipment, and local, state, and federal regulations.

**Design Storage Volume.** The design storage volume equal to the required storage volume, shall consist of the total of the following as appropriate:

- (a) Manure, wastewater, and other wastes accumulated during the storage period
- (b) Normal precipitation less evaporation on the surface area (at the design storage volume level) of the facility during the storage period
- (c) Normal runoff from the facility's drainage area during the storage period
- (d) 25-year, 24-hour precipitation on the surface (at the required design storage volume level) of the facility
- (e) 25-year, 24-hour runoff from the facility's drainage area

- (f) Residual solids after liquids have been removed. A minimum of 6 inches shall be provided for tanks
- (g) Additional storage as may be required to meet management goals or regulatory requirements

**Inlet.** Inlets shall be of any permanent type designed to resist corrosion, plugging, freeze damage and ultraviolet ray deterioration while incorporating erosion protection as necessary.

**Emptying Component.** Some type of component shall be provided for emptying storage facilities. It may be a facility such as a gate, pipe, dock, wet well, pumping platform, retaining wall, or ramp. Features to protect against erosion, tampering, and accidental release shall be incorporated as necessary.

**Accumulated Solids Removal.** Provision shall be made for periodic removal of accumulated solids to preserve storage capacity. The anticipated method for doing this must be considered in planning, particularly in determining the configuration of ponds and type of seal, if any.

**Safety.** Design shall include appropriate safety features to minimize the hazards of the facility. Ramps used to empty liquids shall have a slope of 4 horizontal to 1 vertical or flatter. Those used to empty slurry, semi-solid, or solid waste shall have a slope of 10 horizontal to 1 vertical or flatter unless special traction surfaces are provided. Warning signs, fences, ladders, ropes, bars, rails, and other devices shall be provided, as appropriate, to ensure the safety of humans and livestock. Ventilation and warning signs must be provided for covered waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines shall be provided with a water-sealed trap and vent, or similar device, if there is a potential, based on design configuration, for gases to enter buildings or other confined spaces. Ponds and uncovered fabricated structures for liquid or slurry waste with walls less than 5 feet above ground surface shall be fenced and warning signs posted to prevent children and others from using them for other than their intended purpose.

**Erosion Protection.** Embankments and disturbed areas surrounding the facility shall be treated to control erosion.

**Liners.** Liners shall meet or exceed the criteria in Pond Sealing or Lining (521).

### Additional Criteria for Waste Storage Ponds

**Soil and foundation.** The pond shall be located in soils with an acceptable permeability that meets all applicable regulation, or the pond shall be lined. Information and guidance on controlling seepage from waste impoundments can be found in the Agricultural Waste Management Field Handbook (AWMFH), Appendix 10D.

The pond shall have a bottom elevation that is a minimum of 2 feet above the seasonal high water table unless features of special design are incorporated that address buoyant forces, pond seepage rate and non-encroachment of the water table by contaminants. The water table may be lowered by use of perimeter drains, if feasible, to meet this requirement.

**Maximum Operating Level.** The maximum operating level for waste storage ponds shall be the pond level that provides for the required volume less the volume contribution of precipitation and runoff from the 25-year, 24-hour storm event plus the volume allowance for residual solids after liquids have been removed. A permanent marker or recorder shall be installed at this maximum operating level to indicate when drawdown should begin. The marker or recorder shall be referenced and explained in the O&M plan.

**Outlet.** No outlet shall automatically release storage from the required design volume. Manually operated outlets shall be of permanent type designed to resist corrosion and plugging.

**Embankments.** The minimum elevation of the top of the settled embankment shall be 1 foot above the waste storage pond's required volume. This height shall be increased by the amount needed to ensure that the top elevation will be maintained after settlement. This increase shall be not less than 5 percent. The minimum top widths are shown in Table F-1. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1

vertical, and neither slope shall be steeper than 2 horizontal to 1 vertical unless provisions are made to provide stability.

**Table F-1 – Minimum Top Widths**

Total embankment Height, ft.	Top Width, ft.
15 or less	8
15 – 20	10
20 – 25	12
25 – 30	14
30 – 35	15

**Excavations.** Unless supported by a soil investigation, excavated side slopes shall be no steeper than 2 horizontal to 1 vertical.

## **Additional Criteria for Fabricated Structures**

**Foundation.** The foundations of fabricated waste storage structures shall be proportioned to safely support all superimposed loads without excessive movement or settlement.

Where a non-uniform foundation cannot be avoided or applied loads may create highly variable foundation loads, settlement should be calculated from site-specific soil test data. Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from Table F-2 or another nationally recognized building code. In using presumptive bearing values, adequate detailing and articulation shall be provided to avoid distressing movements in the structure.

Foundations consisting of bedrock with joints, fractures, or solution channels shall be treated or a separation distance provided consisting of a minimum of 1 foot of impermeable soil between the floor slab and the bedrock or an alternative that will achieve equal protection.

**Table F-2 - Presumptive Allowable Bearing Stress Values<sup>1</sup>**

Foundation Description	Allowable Stress
Crystalline Bedrock	12000 psf
Sedimentary Rock	6000 psf
Sandy Gravel or Gravel	5000 psf
Sand, Silty Sand, Clayey Sand, Silty Gravel, Clayey Gravel	3000 psf
Clay, Sandy Clay, Silty Clay, Clayey Silt	2000 psf
<sup>1</sup> Basic Building Code, 12th Edition, 1993, Building Officials and Code Administrators, Inc. (BOCA)	

**Liquid Tightness.** Applications such as tanks, that require liquid tightness shall be designed and constructed in accordance with standard engineering and industry practice appropriate for the construction materials used to achieve this objective.

**Structural Loadings.** Waste storage structures shall be designed to withstand all anticipated loads including internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure and load combinations in compliance with this standard and applicable local building codes.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures in TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values indicated in Table F-3 shall be used.

**TABLE F-3 - LATERAL EARTH PRESSURE VALUES<sup>1</sup>**

		Equivalent fluid pressure (lb/ft <sup>2</sup> /ft of depth)			
Soil		Above seasonal high water table <sup>2</sup>		Below seasonal high water table <sup>3</sup>	
Description <sup>4</sup>	Unified Classification <sup>4</sup>	Free-standing walls	Frame tanks	Free-standing walls	Frame tanks
Clean gravel, sand or sand-gravel mixtures (maximum 5% fines) <sup>5</sup>	GP, GW, SP, SW	30	50	80	90
Gravel, sand, silt and clay mixtures (less than 50% fines) Coarse sands with silt and and/or clay (less than 50% fines)	All gravel sand dual symbol classifications and GM, GC, SC, SM, SC-SM	35	60	80	100
Low-plasticity silts and clays with some sand and/or gravel (50% or more fines) Fine sands with silt and/or clay (less than 50% fines)	CL, ML, CL-ML SC, SM, SC-SM	45	75	90	105
Low to medium plasticity silts and clays with little sand and/or gravel (50% or more fines)	CL, ML, CL-ML	65	85	95	110
High plasticity silts and clays (liquid limit more than 50) <sup>6</sup>	CH, MH	-	-	-	-

<sup>1</sup> For lightly-compacted soils (85% to 90% maximum standard density.) Includes compaction by use of typical farm equipment.

<sup>2</sup> Also below seasonal high water table if adequate drainage is provided.

<sup>3</sup> Includes hydrostatic pressure.

<sup>4</sup> All definitions and procedures in accordance with ASTM D 2488 and D 653.

<sup>5</sup> Generally, only washed materials are in this category

<sup>6</sup> Not recommended. Requires special design if used.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the following conditions:

- **Rigid frame or restrained wall.** Use the values shown in Table F-3 under the column “Frame tanks,” which gives pressures comparable to the at-rest condition.
- **Flexible or yielding wall.** Use the values shown in Table F-3 under the column “Free-standing walls,” which gives pressures comparable to the active condition. Walls

in this category are designed on the basis of gravity for stability or are designed as a cantilever having a base wall thickness to height of backfill ratio not more than 0.085.

Internal lateral pressure used for design shall be 65 lb/ft<sup>2</sup> where the stored waste is not protected from precipitation. A value of 60 lb/ft<sup>2</sup> may be used where the stored waste is protected from precipitation and will not become saturated. Lesser values may be used if supported by measurement of actual pressures of the waste to be stored. If heavy equipment will be operated near the wall, an additional two feet of soil surcharge shall be considered in the wall analysis.

Tank covers shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378.3, Floor and Suspended Loads on Agricultural Structures Due to Use, and in ASAE EP 393.2, Manure Storages, shall be the minimum used. The actual axle load for tank wagons having more than a 2,000 gallon capacity shall be used.

If the facility is to have a roof, snow and wind loads shall be as specified in ASAE EP288.5, Agricultural Building Snow and Wind Loads. If the facility is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

**Structural Design.** The structural design shall consider all items that will influence the performance of the structure, including loading assumptions, material properties and construction quality. Design assumptions and construction requirements shall be indicated on standard plans.

Tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance must be indicated on the construction drawings. The openings in covered tanks shall be designed to accommodate equipment for loading, agitating, and emptying. These openings shall be equipped with grills or secure covers for safety, and for odor and vector control.

All structures shall be underlain by free draining material or shall have a footing located below the anticipated frost depth. Fabricated structures shall be designed according to the criteria in the following references as appropriate:

- Steel: “Manual of Steel Construction”, American Institute of Steel Construction.
- Timber: “National Design Specifications for Wood Construction”, American Forest and Paper Association.
- Concrete: “Building Code Requirements for Reinforced Concrete, ACI 318”, American Concrete Institute.
- Masonry: “Building Code Requirements for Masonry Structures, ACI 530”, American Concrete Institute.

**Slabs on Grade.** Slab design shall consider the required performance and the critical applied loads along with both the subgrade material and material resistance of the concrete slab. Where applied point loads are minimal and liquid-tightness is not required, such as barnyard and feedlot slabs subject only to precipitation, and the subgrade is uniform and dense, the minimum slab thickness shall be 4 inches with a maximum joint spacing of 10 feet. Joint spacing can be increased if steel reinforcing is added based on subgrade drag theory.

For applications where liquid-tightness is required such as floor slabs of storage tanks, the minimum thickness for uniform foundations shall be 5 inches and shall contain distributed reinforcing steel. The required area of such reinforcing steel shall be based on subgrade drag theory as discussed in industry guidelines such as American Concrete Institute, ACI 360, “Design of Slabs-on-Grade”.

When heavy equipment loads are to be resisted and/or where a non-uniform foundation cannot be

avoided, an appropriate design procedure incorporating a subgrade resistance parameter(s) such as ACI 360 shall be used.

## CONSIDERATIONS

Waste storage facilities should be located as close to the source of waste and polluted runoff as practicable.

Non-polluted runoff should be excluded from the structure to the fullest extent possible except where its storage is advantageous to the operation of the agricultural waste management system.

Freeboard for waste storage tanks should be considered.

Solid/liquid separation of runoff or wastewater entering pond facilities should be considered to minimize the frequency of accumulated solids removal and to facilitate pumping and application of the stored waste.

Due consideration should be given to environmental concerns, economics, the overall waste management system plan, and safety and health factors.

### **Considerations for Minimizing the Potential for and Impacts of Sudden Breach of Embankment or Accidental Release from the Required Volume.**

Features, safeguards, and/or management measures to minimize the risk of failure or accidental release, or to minimize or mitigate impact of this type of failure should be considered when any of the categories listed in Table 4 might be significantly affected.

The following should be considered either singly or in combination to minimize the potential of or the consequences of sudden breach of embankments when one or more of the potential impact categories listed in Table 4 may be significantly affected:

1. An auxiliary (emergency) spillway
2. Additional freeboard
3. Storage for wet year rather than normal year precipitation

4. Reinforced embankment -- such as, additional top width, flattened and/or armored downstream side slopes
5. Secondary containment

**Table F-4 - Potential Impact Categories from Breach of Embankment or Accidental Release**

1. Surface water bodies -- perennial streams, lakes, wetlands, and estuaries
2. Critical habitat for threatened and endangered species.
3. Riparian areas
4. Farmstead, or other areas of habitation
5. Off-farm property
6. Historical and/or archaeological sites or structures that meet the eligibility criteria for listing in the National Register of Historical Places.

The following options should be considered to minimize the potential for accidental release from the required volume through gravity outlets when one or more of the potential impact categories listed in Table F-4 may be significantly affected:

1. Outlet gate locks or locked gate housing
2. Secondary containment
3. Alarm system
4. Another means of emptying the required volume

### **Considerations for Minimizing the Potential of Waste Storage Pond Liner Failure.**

Sites with categories listed in Table F-5 should be avoided unless no reasonable alternative exists. Under those circumstances, consideration should be given to providing an additional measure of safety from pond seepage when any of the potential impact categories listed in Table 5 may be significantly affected.

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# Appendix F      National Resource Conservation Service Practice Standards

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**Table F-5 - Potential Impact Categories for  
Liner Failure**

- |   |
|---|
| <ol style="list-style-type: none"><li>1. Any underlying aquifer is at a shallow depth and not confined</li><li>2. The vadose zone is rock</li><li>3. The aquifer is a domestic water supply or ecologically vital water supply</li><li>4. The site is located in an area of solutionized bedrock such as limestone or gypsum.</li></ol> |
|---|

Should any of the potential impact categories listed in Table F-5 be affected, consideration should be given to the following:

1. A clay liner designed in accordance with procedures of AWMFH Appendix 10D with a thickness and coefficient of permeability so that specific discharge is less than  $1 \times 10^{-6}$  cm/sec
2. A flexible membrane liner over a clay liner
3. A geosynthetic clay liner (GCL) flexible membrane liner
4. A concrete liner designed in accordance with slabs on grade criteria for fabricated structures requiring water tightness

## **Considerations for Improving Air Quality**

To reduce emissions of greenhouse gases, ammonia, volatile organic compounds, and odor, other practices such as Anaerobic Digester – Ambient Temperature (365), Anaerobic Digester – Controlled Temperature (366), Waste Facility Cover (367), and Composting Facility (317) can be added to the waste management system.

Adjusting pH below 7 may reduce ammonia emissions from the waste storage facility but may increase odor when waste is surface applied (see Waste Utilization, 633).

Some fabric and organic covers have been shown to be effective in reducing odors.

## **PLANS AND SPECIFICATIONS**

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use.

## **OPERATION AND MAINTENANCE**

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design.

The plan shall contain the operational requirements for emptying the storage facility. This shall include the requirement that waste shall be removed from storage and utilized at locations, times, rates, and volume in accordance with the overall waste management system plan.

In addition, for ponds, the plan shall include an explanation of the permanent marker or recorder installed to indicate the maximum operating level.

The plan shall include a strategy for removal and disposition of waste with the least environmental damage during the normal storage period to the extent necessary to insure the pond's safe operation. This strategy is for the removal of the contribution of unusual storm events that may cause the pond to fill to capacity prematurely with subsequent design inflow and usual precipitation prior to the end of the normal storage period.

Development of an emergency action plan should be considered for waste storage facilities where there is a potential for significant impact from breach or accidental release. The plan shall include site-specific provisions for emergency actions that will minimize these impacts.

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# Appendix G Utility Letter of Request (Sample)

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Date

Mr./Ms.

Customer Service Representative

Name of Electric Utility or Cooperative

P.O. Box No. or Street Address

City, State, Zip Code

Dear Mr. or Ms.:

My farm has recently joined the AgSTAR Program. The AgSTAR Program is a voluntary effort jointly sponsored by the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and the U.S. Department of Energy. The program encourages the production of biogas from animal manures for utilization as a source of energy and to protect air and water quality.

As an AgSTAR partner farm, I am considering the production of biogas on my farm for use as a fuel for the generation of electricity as a small power producer. To complete my assessment of feasibility, I am requesting the following information for my farm, *Farm Name*, located at, *Street Address*, in *City, State, and Zip Code*. My account number is:\_\_\_\_\_.

1. A complete copy of my billing rate schedule.
2. My billing history for the last 12 months showing kWh consumed, peak demand, and associated costs for each billing period.
3. Copies of rate schedules and riders that apply to small (<200 kW) power producers that operate in parallel with the utility excluding peak shaving and other short-term interruptible rates.
4. The name, address, and telephone number of the appropriate contact person in your organization who is responsible for renewable energy projects and can answer questions about terms and conditions of a possible contract for interconnection and the sale of power to you.

Thank you for your assistance. We look forward to working with you in our effort to protect environmental quality and produce electricity from a renewable resource. Should you have any questions, please call me at \_\_\_\_\_.

Sincerely yours,

Note: The manager of environmental affairs and of public relations should be sent a copy of the letter.

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# Appendix H   Interconnection

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# Appendix H Interconnection Requirements

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## H-1. Introduction

In July 2003, the Federal Energy Regulatory Commission (FERC) proposed expedited grid-connection procedures for small generators, such as commercial farms producing and using biogas to generate electricity. FERC divided generators with a capacity of 20 MW or less into three categories. For connecting a generator of 2 MW capacity or less in capacity to a distribution, using pre-certified equipment, FERC proposed “super expedited” procedures that avoid any costly grid connection studies. The procedures for generators with a capacity between 2 and 10 MW will be more complicated but are not likely to include the requirement of a grid connection study. Only generators with more than 10 MW in capacity or connected to a high voltage transmission grid would likely be required to perform a grid connection study.

State Public Utility Commissions will implement the FERC rule when promulgated. Promulgation is expected by the summer of 2004. The expedited interconnection procedures for small generators with 2 MW or less of capacity is in Section H-2. For the complete FERC rule, *Standardized Interconnection Agreements and Procedures for Small Generators*, and links to fact sheets, visit the FERC web site at [www.ferc.gov](http://www.ferc.gov).

As discussed in Chapter 5, there are several types of possible agreements for the sale of electricity generated using biogas to a utility. However, the options that are available will vary depending on Public Utility Commission regulations in the state. In addition, contractual requirements also will vary by state and utility. Examples of complex and simple contractual requirements for surplus sale agreements are presented in Sections H-3 and H-4, respectively. One feature of the more complex program is the requirement for a standby service rider. An example of a net metering program and tariff is presented in Section H-5.

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# Appendix H Interconnection Requirements

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## **H-2. STANDARD AGREEMENT FOR INTERCONNECTION AND PARALLEL OPERATION BY SMALL GENERATING SYSTEMS (2003 FERC PROPOSED RULE)**

Docket No. RM02-12-000

**Expedited Interconnection Procedures – Small Generators (up to and including 2 MW)**  
(To be included with Section 14.2.3 of the Interconnection Procedures  
under consideration in FERC Docket RM02-1-000)

1. Application and Definitions

- a. This expedited interconnection procedure is available for small generators up to and including 2 MW in size that will participate in a FERC regulated market, sell power for resale in interstate commerce or are interconnected to a FERC regulated transmission line. These procedures apply only to generators that meet certain national standards addressing technical requirements for continuous interconnected operation of small generators. In addition the generator must meet certain criteria regarding the relationship between the size of the generator and the size of the circuit to which they will interconnect. Small generators meeting these standards are entitled to a presumption of approval of the interconnection without additional testing, fees, or other requirements imposed by the interconnecting Transmission Provider or any Affected System utility.

Although generators meeting all the standards herein are entitled to a presumption of approval, the presumption is rebuttable. Should the Transmission Provider or Affected System petition the FERC to require additional testing because of special circumstances and received Commission approval, the generator would then have to undergo additional testing and interconnection study at the generator's expense.

- b. Definitions: Unless otherwise defined herein, terms shall have the meanings specified in Article 1 of the Standard Generator Interconnection Procedures issued in FERC Docket No. RM02-1-000

2. National Codes and Standards

Small generators must comply with all national codes and standards applicable to the ongoing interconnected operation of a small generator with the electricity grid.

Docket No. RM02-12-000

3. Technical Requirements

Under the national codes and standards applicable to small interconnected generators, a generator may not energize or re-energize a circuit unless grid voltage is present and within normal operating bounds. A small generator must immediately and automatically disconnect from the grid and cease interconnected operations any time the grid is de-energized or outside of normal operating bounds. The codes and standards also dictate acceptable operating conditions for the small generators including, but not limited to, voltage, frequency and harmonics.

4. Threshold for Determination of the Presumption of No Grid Impact

For interconnections on radial circuits the small generator (in aggregate with other generation on the circuit) may not exceed 15 percent of the total measured peak load or design capacity of the circuit (as most recently measured at the substation). For interconnections on networked circuits, the small generator (in aggregate with other generation on the circuit) may not exceed 25 percent of the minimum measured load on the circuit. A small generator may not contribute more than 25 percent of the maximum short circuit current at the point of interconnection.

5. Analysis of Interconnection - Limited Interconnection Studies - Costs

If a small generator meets all of the criteria in Sections 1 - 4, the impact and facilities studies are waived. A limited feasibility study may be conducted to determine compliance with the load and short circuit contributions in Section 4. This study must be completed in 15 days after acceptance of a valid interconnection request. Costs to the generator are waived if short circuit calculations have recently been performed in the area of the interconnection or if the short circuit and load thresholds are sufficiently greater than the generator capacity that no calculations are needed.

6. Disputes

If a dispute arises during the application of these procedures, either the generator or Transmission Provider may seek immediate resolution through FERC's alternative dispute resolution process. At the generator's option, dispute resolution will be binding. Alternative dispute resolution may include any dispute

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resolution services made available by the FERC including those that occur by telephone.

Should a Transmission Provider desire a waiver from these procedures that would otherwise apply to the small generator interconnection, the Transmission Provider must seek such waiver from FERC within 15 days of the receipt of a valid small generator interconnection request. The Transmission Provider shall have the burden to show, in a clear and convincing manner, why the application of these rules would result in an unsafe or unreliable interconnection or that the interconnection would interfere with the quality of electric service to other customers.

7. Capacity and Energy. Metering.

Small generators are entitled to participate in any available energy and capacity markets and receive the appropriate compensation due to participants in those markets. Metering shall be installed as needed to participate in the various markets.

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**STANDARD AGREEMENT FOR INTERCONNECTION AND PARALLEL OPERATION OF SMALL GENERATION SYSTEMS (Pre-certified systems up to and including 2 MW)**

This Interconnection Agreement ("Agreement") is made and entered into this \_\_\_\_\_ day of \_\_\_\_\_, 19\_\_\_\_, by \_\_\_\_\_, ("Transmission Provider"), and \_\_\_\_\_ ("Generator"), a [specify whether corporation, and if so name state, municipal corporation, cooperative corporation, or other], each hereinafter sometimes referred to individually as "Party" or both referred to collectively as the "Parties". In consideration of the mutual covenants set forth herein, the Parties agree as follows:

**1. Definitions**

Unless otherwise defined herein, terms in this Agreement shall have the meanings specified in Article 1 of the STANDARD GENERATOR INTERCONNECTION AND OPERATING AGREEMENT (IA) issued in FERC Docket No. RM02-1-000.

**2. Scope of Agreement** -- This Agreement is applicable to conditions under which the Transmission Provider and the Generator agree that one or more generating facility or facilities up to and including two (2) MW to be interconnected to the Transmission Provider's system, as described in Exhibit A.

**3. Establishment of Point(s) of Interconnection** -- Transmission Provider and Generator agree to interconnect the Facility at the locations specified in this Agreement and in accordance with Federal Energy Regulatory Commission Rules relating to Interconnection of Small Generation systems.

**4. Responsibilities of Transmission Provider and Generator** -- Each Party will, at its own cost and expense, operate, maintain, repair, and inspect, and shall be fully responsible for, Facility or Facilities which it now or hereafter may own unless otherwise specified on Exhibit A. Generator shall conduct operations of its facility(s) in compliance with all aspects of the Rules, and Transmission Provider shall conduct operations on its utility system in compliance with all aspects of the Rules, or as further described and mutually agreed to in the applicable Facility Schedule. Maintenance of Generator and associated interconnection equipment shall be performed in accordance with the applicable manufacturer's recommended maintenance schedule. The Parties agree to cause their Facilities or systems to be constructed in accordance with applicable specifications equal to or greater than those provided by the National Electrical Safety Code, the American National Standards Institute, IEEE and Underwriter's Laboratory in effect at the time of construction. Each Party covenants and agrees to design, install, maintain, and operate, or cause the design, installation, maintenance, and operation of its transmission and distribution system and related Facilities and Units so as to reasonably minimize the likelihood of a disturbance, originating in the system of one Party, affecting or impairing the system of the other Party, or other systems with which a Party is interconnected.

Transmission Provider will notify Generator if there is evidence that the operation of Generator's equipment causes disruption or deterioration of service to other customers served from the same grid or if the generator operation causes damage to Transmission Provider's or Affected Systems. Generator will notify Transmission Provider of any emergency or hazardous condition or occurrence with the Generator's Unit(s) which could affect safe operation of the system.

**5. Limitation of Liability and Indemnification**

The Parties shall at all times indemnify, defend, and save the other Party harmless from, any and all damages, losses, claims, including claims and actions relating to injury to or death of any person or damage to property, demand, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from the other Party's performance of obligations under this Agreement on behalf of the indemnifying Party, except in cases of negligence or intentional wrongdoing by the indemnifying Party.

**6. Right of Access, Equipment Installation, Removal & Inspection**— Upon reasonable notice, the Transmission Provider may send a qualified person to the premises of the Generator at or immediately before the time the Facility first produces energy to inspect the interconnection, and observe the Facility's commissioning (including any testing), startup, and operation for a period of up to no more than three days after initial startup of the unit.

## Docket No. RM02-12-000

Following the initial inspection process described above, at reasonable hours, and upon reasonable notice, or at any time without notice in the event of an emergency or hazardous condition, Transmission Provider shall have access to Generator's premises for any reasonable purpose in connection with the performance of the obligations imposed on it by this Agreement or if necessary to meet its legal obligation to provide service to its customers.

**7. Disconnection of Unit** – Generator retains the option to disconnect from Transmission Provider's utility system. Generator will notify the Transmission Provider of its intent to disconnect by giving the Transmission Provider at least thirty days' prior written notice. Such disconnection shall not be a termination of the agreement unless Generator exercises rights under Section 7.

Generator shall disconnect Facility from Transmission Provider's system upon the effective date of any termination under Section 7.

Subject to Commission Rule, for routine maintenance and repairs on Transmission Provider's utility system, Transmission Provider shall provide Generator with seven business days' notice of service interruption. Transmission Provider shall have the right to suspend service in cases where continuance of service to Generator will endanger persons or property. During the forced outage of the Transmission Provider's utility system serving Generator, Transmission Provider shall have the right to suspend service to effect immediate repairs on Transmission Provider's utility system, but the Transmission Provider shall use its best efforts to provide the Generator with reasonable prior notice.

**8. Effective Term and Termination Rights**-- This Agreement becomes effective when executed by both parties and shall continue in effect until terminated. The agreement may be terminated for the following reasons:

(a) Generator may terminate this Agreement at any time, by giving the Transmission Provider sixty days' written notice;

(b) Transmission Provider may terminate upon failure by the Generator to generate energy from the Facility in parallel with the Transmission Provider's system within twelve months after completion of the interconnection;

(c) either party may terminate by giving the other party at least sixty days prior written notice that the other Party is in default of any of the material terms and conditions of the Agreement, so long as the notice specifies the basis for termination and there is reasonable opportunity to cure the default; or

(d) Transmission Provider may terminate by giving Generator at least sixty days notice in the event that there is a material change in an applicable rule or statute.

**9. Governing Law and Regulatory Authority** -- The validity, interpretation and performance of this Agreement and each of its provisions shall be governed by the laws of the State where the Point of Interconnection is located, without regard to its conflicts of law principles. This Agreement is subject to all Applicable Laws and Regulations. Each Party expressly reserves the right to seek changes in, appeal, or otherwise contest any laws, orders, rules, or regulations of a Governmental Authority.

**10. Amendment** --This Agreement may be amended only upon mutual agreement of the Parties, which amendment will not be effective until reduced to writing and executed by the Parties.

**11. Entirety of Agreement and Prior Agreements Superseded** -- This Agreement, including all attached Exhibits and Facility Schedules, which are expressly made a part hereof for all purposes, constitutes the entire agreement and understanding between the Parties with regard to the interconnection of the facilities of the Parties at the Points of Interconnection expressly provided for in this Agreement. The Parties are not bound by or liable for any statement, representation, promise, inducement, understanding, or undertaking of any kind or nature (whether written or oral) with regard to the subject matter hereof not set forth or provided for herein. This Agreement replaces all prior agreements and undertakings, oral or written, between the Parties with regard to the subject matter hereof, including without limitation [specify any prior agreements being superseded], and all such agreements and undertakings are agreed by the Parties to no longer be of any force or effect. It is expressly acknowledged that the Parties may have other agreements covering other services not expressly provided for herein, which agreements are unaffected by this Agreement.

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**12. Notices** -- Notices given under this Agreement are deemed to have been duly delivered if hand delivered or sent by United States certified mail, return receipt requested, postage prepaid, to:

(a) If to Transmission Provider:

(b) If to Generator:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

The above-listed names, titles, and addresses of either Party may be changed by written notification to the other, notwithstanding Section 10.

**13. Invoicing and Payment** -- Invoicing and payment terms for services associated with this agreement shall be consistent with applicable Rules of the Commission.

**14. No Third-Party Beneficiaries** -- This Agreement is not intended to and does not create rights, remedies, or benefits of any character whatsoever in favor of any persons, corporations, associations, or entities other than the Parties, and the obligations herein assumed are solely for the use and benefit of the Parties, their successors in interest and, where permitted, their assigns.

**15. No Waiver** -- The failure of a Party to this Agreement to insist, on any occasion, upon strict performance of any provision of this Agreement will not be considered to waive the obligations, rights, or duties imposed upon the Parties.

**16. Headings** -- The descriptive headings of the various articles and sections of this Agreement have been inserted for convenience of reference only and are to be afforded no significance in the interpretation or construction of this Agreement.

**17. Multiple Counterparts** -- This Agreement may be executed in two or more counterparts, each of which is deemed an original but all constitute one and the same instrument.

IN WITNESS WHEREOF, the Parties have caused this Agreement to be signed by their respective duly authorized representatives.

[Transmission Provider NAME]

BY: \_\_\_\_\_

TITLE: \_\_\_\_\_

DATE: \_\_\_\_\_

[Transmission owner NAME (if different from Transmission Provider)]

BY: \_\_\_\_\_

TITLE: \_\_\_\_\_

DATE: \_\_\_\_\_

[Generator NAME]

BY: \_\_\_\_\_

TITLE: \_\_\_\_\_

DATE: \_\_\_\_\_

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**EXHIBIT A to the agreement**

**FACILITY SCHEDULE NO. \_\_\_\_\_**

[The following information is to be specified for each Point of Interconnection, if applicable.]

1. Name:
2. Facility location:
3. Delivery voltage:
4. Metering (voltage, location, losses adjustment due to metering location, and other):
5. Normal Operation of Interconnection:
6. One line diagram attached (check one): \_\_\_\_\_ Yes / \_\_\_\_\_ No
7. Facilities to be furnished by Transmission Provider (usually none):
8. Facilities to be furnished by Generator (usually contained with pre-certified generator):
9. Cost Responsibility (if any):
10. Control area interchange \_\_\_\_\_
11. Supplemental terms and conditions attached (check one): \_\_\_\_\_ Yes / \_\_\_\_\_ No

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**EXHIBIT B to the agreement**

**Small Generator Interconnection Application**

(For use with Generators up to and including 2 MW)

An applicant (Generator Owner) makes application to \_\_\_\_\_ (Transmission Provider) to install and operate a generating facility up to and including 2 MW interconnected with the \_\_\_\_\_ utility system.. This application, unless otherwise established at the scoping meeting between Generator Owner and Transmission Provider, will be considered as application for a feasibility study for generators under Federal Energy Regulatory Commission rules for expedited treatment of generators up to and including 2 MW in capacity.

**Section 1, Applicant Information**

Name: \_\_\_\_\_

Mailing Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Zip Code: \_\_\_\_\_

Facility Location (if different from above): \_\_\_\_\_

Telephone (Daytime): Area Code \_\_\_\_\_ Number \_\_\_\_\_ (Evening) Area Code \_\_\_\_\_ Number \_\_\_\_\_

Account No. (if applicable): \_\_\_\_\_ Pole Number: \_\_\_\_\_

Energy Service Provider Name: \_\_\_\_\_

**Section 2, Generator Qualifications**

(informational only) Is the generator a Qualifying Facility as defined under Subpart B, Section 201 of the Federal Energy Regulatory Commission's regulations per the Public Utility Regulatory Policies Act of 1978?

\_\_\_\_\_ Yes \_\_\_\_\_ No

Is Generator powered from a Renewable Qualifying Energy Source: \_\_\_\_\_ Yes \_\_\_\_\_ No

Type Qualifying Energy Source (if applicable): \_\_\_\_\_ Solar \_\_\_\_\_ Wind \_\_\_\_\_ Hydro \_\_\_\_\_ Other

Other generator energy source: \_\_\_\_\_ Diesel, Natural Gas \_\_\_\_\_ Diesel, Fuel Oil \_\_\_\_\_ Other: \_\_\_\_\_  
(State type)

Will excess power be exported? \_\_\_\_\_ Yes \_\_\_\_\_ No

Site Load: \_\_\_\_\_ kW (Typical) Maximum Export: \_\_\_\_\_ kW.

**Section 3, Generator Technical Information**

Type of Generator: \_\_\_\_\_ Synchronous \_\_\_\_\_ Induction \_\_\_\_\_ DC Generator or Solar with Inverter

Generator (or solar collector) Manufacturer, Model Name & Number: \_\_\_\_\_

(A copy of Generator Nameplate and Manufacturer's Specification Sheet may be substituted)

Output Power Rating in kW: \_\_\_\_\_ Single phase \_\_\_\_\_ Three phase

Inverter Manufacturer, Model Name & Number (if used): \_\_\_\_\_

Docket No. RM02-12-000

Adjustable Setpoints \_\_\_\_\_

(A copy of Inverter Manufacturer's Specification Sheet may be substituted)

**Generator Characteristic Data (for rotating machines):**

(Not needed if Generator Nameplate and Manufacturer's Specification Sheet is provided)

Direct Axis Synchronous Reactance,  $X_d$ : \_\_\_\_\_ P.U.      Negative Sequence Reactance: \_\_\_\_\_ P.U.  
Direct Axis Transient Reactance,  $X'_d$ : \_\_\_\_\_ P.U.      Zero Sequence Reactance: \_\_\_\_\_ P.U.  
Direct Axis Subtransient Reactance,  $X''_d$ : \_\_\_\_\_ P.U.      KVA Base: \_\_\_\_\_

**Section 4, Interconnecting Equipment Technical Data**

Will an interposing transformer be used between the generator and the point of interconnection? \_\_\_\_ Yes \_\_\_\_ No

Transformer Data (if applicable, for Customer Owned Transformer):

**(A copy of transformer Nameplate and Manufacturer's Test Report may be substituted)**

Size: \_\_\_\_\_ KVA .      Transformer Primary : \_\_\_\_\_ Volts    \_\_\_\_ Delta \_\_\_\_ Wye \_\_\_\_ Wye Grounded

Transformer Secondary: \_\_\_\_\_ Volts    \_\_\_\_ Delta \_\_\_\_ Wye \_\_\_\_ Wye Grounded

Transformer Impedance: \_\_\_\_\_ % on \_\_\_\_\_ KVA Base

Transformer Fuse Data (if applicable, for Customer Owned Fuse):

(Attach copy of fuse manufacturer's Minimum Melt & Total Clearing Time-Current Curves)

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Size: \_\_\_\_\_ Speed: \_\_\_\_\_

Interconnecting Circuit Breaker (if applicable):

(A copy of breaker's Nameplate and Specification Sheet may be substituted)

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Load Rating: \_\_\_\_\_ Interrupting Rating: \_\_\_\_\_ Trip Speed: \_\_\_\_\_  
(Amps) (Amps) (Cycles)

Circuit Breaker Protective Relays (if applicable):

(Enclose copy of any proposed Time-Overcurrent Coordination Curves)

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Style/Catalog No.: \_\_\_\_\_ Proposed Setting: \_\_\_\_\_

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Style/Catalog No.: \_\_\_\_\_ Proposed Setting: \_\_\_\_\_

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Style/Catalog No.: \_\_\_\_\_ Proposed Setting: \_\_\_\_\_

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Style/Catalog No.: \_\_\_\_\_ Proposed Setting: \_\_\_\_\_

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Style/Catalog No.: \_\_\_\_\_ Proposed Setting: \_\_\_\_\_

Current Transformer Data (if applicable):

(Enclose copy of Manufacturer's Excitation & Ratio Correction Curves)

Docket No. RM02-12-000

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Accuracy Class: \_\_\_\_\_ Proposed Ratio Connection: \_\_\_\_\_/5

Manufacturer: \_\_\_\_\_ Type: \_\_\_\_\_ Accuracy Class: \_\_\_\_\_ Proposed Ratio Connection: \_\_\_\_\_/5

**Section 5, General Technical Information**

Enclose copy of site One-Line Diagram showing configuration and interconnection of all equipment, current and potential circuits and protection and control schemes. Is One-Line Diagram Enclosed?: \_\_\_\_\_ Yes

Enclose copy of any site documentation that describes and details the operation of the protection and control schemes. Is Any Available Documentation Enclosed?: \_\_\_\_\_ Yes

Enclose copies of schematic drawings for all protection and control circuits, relay current circuits, relay potential circuits, and alarm/monitoring circuits (if applicable). Are Schematic Drawings Enclosed? \_\_\_\_\_ Yes

**Section 6, Installation Details**

Installing Electrician: \_\_\_\_\_ Firm: \_\_\_\_\_ License No.: \_\_\_\_\_

Mailing Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Zip Code: \_\_\_\_\_

Telephone: Area Code: \_\_\_\_\_ Number: \_\_\_\_\_

Installation Date: \_\_\_\_\_ Interconnection Date: \_\_\_\_\_

Supply certification that the generating system has been installed and inspected in compliance with the local Building/Electrical code of the municipality of \_\_\_\_\_

Signed (Inspector): \_\_\_\_\_ Date: \_\_\_\_\_

(In lieu of signature of Inspector, a copy of the final inspection certificate may be attached)

**Section 7, Generator/Equipment Certification**

Generating systems must be compliant with *IEEE, NEC, ANSI, and UL standards*. **By signing below, the Applicant certifies that the installed generating equipment meets the appropriate preceding requirement(s) and can supply documentation that confirms compliance.**

Signed (Applicant): \_\_\_\_\_ Date: \_\_\_\_\_

**Section 8, Applicant Signature**

**I hereby certify that, to the best of my knowledge, all the information provided in the Interconnection Application is true and correct. I also agree to install a Warning Label provided by (utility) on or near my service meter location.**

Docket No. RM02-12-000

Signature of Applicant: \_\_\_\_\_ Date: \_\_\_\_\_

Send the completed application to:

(Utility Address)

This section for use by \_\_\_\_\_(utility) Only

**Section 9, Approval or Non-Approval**

(utility): \_\_\_\_\_Has Approved \_\_\_\_\_Has Not Approved this Interconnection Application.

Name : \_\_\_\_\_ Date: \_\_\_\_\_

Signature: \_\_\_\_\_

Reason for Not Approving:

**Approval to connect to the Company system indicates only that the minimum requirements for a safe proper interconnection have been satisfied. Such approval does not imply that the Generator Owner's facility meets all federal, state and local standards or regulations.**

**Section 10, Internal Notifications**

Send Applicant Warning Label for installing on/ near service meter: \_\_\_\_\_Yes

Notify Billing Dept. of Interconnected Generation: \_\_\_\_\_Yes

Notify District Engineering of Interconnected Generation: \_\_\_\_\_Yes

Notify System Protection of Interconnected Generation: \_\_\_\_\_Yes

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# Appendix H Interconnection Requirements

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## **H-3. EXAMPLE OF A COMPLEX SURPLUS SALE TARIFF**



Northern States Power Company  
Minneapolis, Minnesota 55401

**MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2**

**STANDBY SERVICE RIDER**

Section No. 5  
1<sup>st</sup> Revised Sheet No. 101

**AVAILABILITY**

Available to any non-residential customer who has an alternative source of electric energy supply which normally serves all or a portion of the customer's electrical load requirements and who desires use of the Company's electric service for temporary backup or maintenance power. Under this service the Company will provide a permanent service connection to supply the customer's contracted load in accordance with the provisions in the General Rules and Regulations, Section 2.4.

**RESERVATION FEES**

	<u>Firm Standby</u>			R
	<u>Unscheduled Maintenance</u>	<u>Scheduled Maintenance</u>	<u>Non-Firm Standby</u>	
Customer Charge per Month	\$17.36	\$17.36	\$17.36	
Demand Charge per Month per kW of Contracted Standby Capacity				
Secondary Voltage Service	\$3.25	\$3.15	\$2.35	
Primary Voltage Service	\$2.30	\$2.20	\$1.40	
Transmission Transformed Voltage Service	\$1.50	\$1.40	\$0.60	
Transmission Voltage Service	\$0.90	\$0.80	\$0.00	
Annual Allowed Grace Period of Unscheduled Use of Standby Service for Exemption from Demand Usage Rates (Hours per kW of Contracted Standby Capacity)	964	964	0	

**USAGE RATES**

Demand Charge per Month per kW of Standby Capacity Used. Capacity actually used under this Rider will be charged at the same demand rate as contained in the base tariff to which this Rider is attached.

Energy Charge per kWh of Standby Energy Used. Energy actually used under this Rider will be charged at the same energy rate as contained in the base tariff to which this Rider is attached.

**RESOURCE ADJUSTMENT**

Bills are subject to the adjustments provided for in the Fuel Clause Rider and in the Conservation Improvement Program Adjustment Rider.

(Continued on Sheet No. 5-102)

Date Filed: 07-13-01

By: Kent T. Larson  
State Vice President, Minnesota

Effective Date: 10-01-01

Docket No. E002/M-01-1087

Order Date: 09-14-01



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**STANDBY SERVICE RIDER (Continued)**

Section No. 5  
1<sup>st</sup> Revised Sheet No. 102

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**SURCHARGE**

In certain communities, bills are subject to surcharges provided for in a Surcharge Rider.

**LATE PAYMENT CHARGE**

Any unpaid balance over \$10.00 is subject to a 1.5% late payment charge or \$1.00, whichever is greater, after the date due. The charge may be assessed as provided for in the General Rules and Regulations, Section 3.5.

**DETERMINATION OF DEMAND**

For billing purposes, the customer demand for this Standby Service Rider will be determined separately from the billing demand determined under the tariff to which this Rider applies. For purposes of applying the Reservation Fee, the demand will be the quantity specified in the customer's Electric Service Agreement as the maximum amount of Standby Service the Company is obligated to supply. This quantity may be different between the summer and winter seasons. For applying the Usage Rate, the demand will be the smaller of the following two amounts: (1) the amount of the Standby capacity contracted for by the customer minus the actual demand supplied by the customer's own generating facilities, but not less than zero, or (2) the amount of actual capacity supplied by the Company. This amount of used Standby service demand will be determined independent of and will have no effect on the billing demand of the customer under their base tariff including any demand ratchet provisions of that base tariff.

**TERMS AND CONDITIONS OF SERVICE**

1. Standby Service Rider is applicable to any non-residential customer who requires 40 kW or more of Standby capacity from the Company. Standby Service may not be used by a customer to serve controllable demand that is subject to interruption as determined by the Company under the Company's controllable service schedules, however, customer will always be permitted to implement demand side load reductions or use alternative generation capacity when necessary, due to full or partial outage of the customer's generator, instead of using Standby Service from the Company.
2. Customer will execute an Electric Service Agreement with the Company which will specify:
  - a. Type of Standby Service elected by the customer and the base tariff that this Rider is attached to and under which demand and energy rates will be selected during months Standby power is used.
  - b. The total Standby capacity requirements for which Company will be providing Standby power and to which the Standby Service reservation fee applies as well as the expected level of firm service the customer will take, even if that level is zero.

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(Continued on Sheet No. 5-103)

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State Vice President - Minnesota & Dakotas

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Docket No. E,G002/M-01-937

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Northern States Power Company  
Minneapolis, Minnesota 55401

**MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2**

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**STANDBY SERVICE RIDER (Continued)**

Section No.	5
Original Sheet No.	103
Relocated from MPUC No. 1 Sheet No.	5-28.1 & 5-28.2

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**TERMS AND CONDITIONS OF SERVICE (Continued)**

3. The Company's meter will be ratcheted to measure the flow of power and energy from Company to customer only.
4. Company will not be obligated to supply Standby Service to back-up a customer's generator at a level in excess of the Standby capacity for which customer has contracted. This restriction in no way limits the amount of load for which a customer may require service from the Company under the base tariff to which this Rider is attached.
5. Customer will be liable for all damages allowed by law to the extent caused by customer's use of Standby power in excess of contracted Standby capacity.
6. Company will require customer to contract for additional Standby and Supplemental capacity if the customer exceeds the contract amount in any three of the preceding 12 months.
7. Customer will annually furnish documentation to Company confirming the maximum capacity and reliability of the power source for which customer requires Standby Service. The Company and the customer will review the actual output and performance of the power source relative to the capacity nominated for Standby Service in the Electric Service Agreement. If this review shows a significant and consistent shortfall between the power source's actual performance and the nominated capacity due to factors reasonably within the customer's control, the Company will notify the customer of its intent to refuse to provide Standby Service. Upon receipt of such notice, the customer may agree to reduce the Standby Service nomination in its Electric Service Agreement or to take such action as necessary to operate the power source at or reasonably near the nominated Standby Service capacity. If the customer's power source does not operate at or reasonably near that level during the 12 months immediately following the Company's notice, the Company may refuse to provide Standby Service until such time as the customer agrees to reduce its Standby Service nomination or provide the Company with documentation demonstrating the power source's actual performance at or reasonably near the nominated Standby Service capacity for a trial period of three consecutive months.
8. Customer will remain on Standby Service for a period of not less than 12 months.

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(Continued on Sheet No. 5-104)

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Northern States Power Company  
Minneapolis, Minnesota 55401

**MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2**

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**STANDBY SERVICE RIDER (Continued)**

Section No. 5  
Original Sheet No. 104  
Relocated from MPUC No. 1 Sheet No. 5-28.2 &  
5-28.3

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**TERMS AND CONDITIONS OF SERVICE (Continued)**

9. Customer will be allowed annually a grace period as specified above for use of unscheduled Standby Service without incurring additional demand charges for use of Standby Service. Use of this grace period will be measured in terms of Standby energy used by customer with the maximum amount of grace energy being the hours specified above times the contracted Standby capacity. After the grace period has been exhausted and customer uses unscheduled Standby Service, the customer shall pay the Usage Rates instead of the Reservation Fees as listed above. In a billing month, when customer uses Standby Service, the base tariff billing demand and the Standby Service billing demand will be determined individually. The base tariff billing demand will be the greatest 15 minute load determined after separating Standby Service usage from the total metered demands. The time of this determined greatest 15 minute demand may or may not be at the same time when Standby Service is used. Billed demand charges for usage of Standby Service will be in addition to the billed demand charges for the base tariff as just described.
10. Notwithstanding the grace period noted in Section 9 above, in the event customer requires unscheduled Standby Service at the times of Company's system peak hours in which the Company would have insufficient accredited capacity under the Mid-Continent Area Power Pool (MAPP) Agreement, if not for additional capacity purchases, and the Company incurs additional capacity costs as a result of such unscheduled Standby Service, customer shall pay peak demand charges for the month in which such unscheduled Standby Service occurs and for each of the five succeeding months instead of the above listed demand charges, or the demand charges under Section 9 above. Such peak demand charges shall be based upon the following:
  - a. If customer has notified Company of an unscheduled outage at least three hours prior to Company's system peak hour, such peak demand charges shall be based on one-sixth of any additional capacity costs incurred by the Company as a result of the unscheduled outage. Such additional capacity costs shall not include any MAPP after-the-fact capacity purchase costs incurred by the Company.
  - b. If customer has not notified the Company of any unscheduled outage at least three hours prior to the Company's system peak hour, such peak demand charges shall be based on one-sixth of any additional capacity costs or MAPP after-the-fact purchase costs incurred by the Company as a result of the unscheduled outage. The demand for billing purposes for the succeeding five months shall be equal to the demand placed on the system during the time of the Company's system peak hour.

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(Continued on Sheet No. 5-105)

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Minneapolis, Minnesota 55401

**MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2**

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**STANDBY SERVICE RIDER (Continued)**

Section No. 5  
Original Sheet No. 105  
Relocated from MPUC No. 1 Sheet No. 5-28.3

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**TERMS AND CONDITIONS OF SERVICE (Continued)**

11. In the event any portion of the capacity associated with the additional capacity costs or MAPP after-the-fact purchase costs incurred by the Company and attributable to the customer under Section 10 above are subsequently used to satisfy the Company's MAPP requirements for the Company's customers, the peak demand charges under Section 10 shall be discounted with respect to that portion subsequently used by the Company's customers.
12. The Company shall provide notice to the Standby customers when peak load conditions are expected to occur through the same means that the Company notifies interruptible customers of the potential interruption.
13. Company will install and charge customer for the metering necessary, as determined by the Company, to allow for proper billing of the separate base tariff and Standby Rider demands and grace period identified above. Customer shall reimburse the Company for the costs of installing, operating, and maintaining these meters and any other facilities required to serve the customer's Standby load. Such required additional equipment shall include the metering equipment used to measure the electrical output of the customers' alternative source of electric energy supply. In particular, the Company will install a meter that measures the flow of power and energy from the customer's own generating facility. If, as a result of the customer's construction and installation of their generating facility, it is more practical or economical for the customer to install some or all of the metering equipment required, the customer may be permitted to do so subject to Company's approval of an installation plan for such equipment.

(Continued on Sheet No. 5-106)

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**STANDBY SERVICE RIDER (Continued)**

Section No. 5  
1<sup>st</sup> Revised Sheet No. 106

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**ADDITIONAL TERMS AND CONDITIONS OF SERVICE WITH FIRM STANDBY SCHEDULED MAINTENANCE**

1. Scheduled maintenance rates are available to Standby Service customers who agree to schedule maintenance of their power source during qualifying scheduled maintenance periods.
2. Qualifying Scheduled Maintenance Periods

Customers With 40 kW to 10,000 kW of Contracted Standby Capacity. Maintenance must occur within the calendar months of April, May, October, and November. Customer must provide Company with written notice of scheduled maintenance prior to the beginning of the maintenance period.

Customers With Greater Than 10,000 kW of Contracted Standby Capacity. Maintenance must occur at a time period mutually agreed to by Company and customer. These time periods will normally not include those times when Company expects system seasonal peak load conditions to occur, and at those times when Company is required to use oil-fired generation equipment or to purchase power that results in equivalent production costs. Customer shall provide an annual projection of scheduled maintenance to the Company. Customer shall be allowed changes or additions to this projection upon notice to the Company based on the following schedule:

<u>Outage Length</u>	<u>Required Notice</u>
Less than 48 hours	24 hours
2 days to 30 days	7 days
Over 30 days	90 days

3. The duration of qualifying scheduled maintenance periods may not exceed a total of six weeks in any 12 month period.
4. An additional charge shall apply if customer does not comply with all terms and conditions for qualifying scheduled maintenance periods. The additional charge shall be determined by calculating the additional charges which would have applied if customer were billed on the Unscheduled Maintenance Option for the period extending back to the customer's last scheduled maintenance period.
5. General Service or General Time of Day Service demand charges shall not apply to use during qualifying scheduled maintenance periods. Further, qualifying scheduled maintenance period time and energy will not count against the grace period.

(Continued on Sheet No. 5-107)

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State Vice President – Minnesota & Dakotas

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Northern States Power Company  
Minneapolis, Minnesota 55401

**MINNESOTA ELECTRIC RATE BOOK - MPUC NO. 2**

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**STANDBY SERVICE RIDER (Continued)**

Section No. 5  
Original Sheet No. 107  
Relocated from MPUC No. 1 Sheet No. 5-29

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**ADDITIONAL TERMS AND CONDITIONS OF SERVICE FOR NON-FIRM STANDBY OPTION**

1. Non-firm standby rates are available to customers who agree to use Standby Service only by prearrangement with the Company.
2. Company makes no guarantee that Standby Service will be available to Non-Firm Standby Service customers; however, the Company will make reasonable efforts to provide Standby Service whenever possible.
3. Customer must request use of Standby Service and receive approval from the Company prior to actually using Standby Service.
4. Use of Standby Service without prior approval by the Company shall subject the Non-Firm Standby Service customer to the following:
  - a. General Service or General Time of Day Service monthly demand charges for the unapproved Standby Service used in a given month, plus
  - b. Firm Standby Service unscheduled maintenance option reservation fees for six months prior to the month in which unapproved use of Standby Service occurred.
5. If unapproved use of Standby Service occurs twice in any 12 month period, the Company reserves the right to convert the Non-Firm Standby Service customer to Firm Standby Service.
6. Non-Firm Standby Service customers will remain on Non-Firm Standby Service for a period of not less than five years which includes a one year trial period.

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# Appendix H Interconnection Requirements

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## H-4. EXAMPLE OF SIMPLE SURPLUS SALE TARIFF

**SMALL POWER PRODUCER RIDER  
TIME-OF-DAY PURCHASE RATES**

Firm Power	Rate Zones 1 & 9	Code 40-982
Nonfirm Power	Rate Zones 1 & 9	Code 40-983

**AVAILABILITY:** Available to any qualifying facility with generation capacity of 100 kw or less, and available to qualifying facilities with capacity of more than 100 kw if firm power is provided.

<b><u>METERING CHARGE:</u></b>	Firm Power	\$8.87 per month
	Nonfirm Power	\$3.25 per month

**PAYMENT SCHEDULE:** For energy delivered to the utility.

	Capacity Payment (On-Peak Only)	Energy Payment		
		On-Peak	Off-Peak	
Summer	1.700¢ per kWh	2.120¢ per kWh	1.710¢ per kWh	-R- -I- -I-
Winter	1.700¢ per kWh	2.270¢ per kWh	1.890¢ per kWh	-R- -I- -I-

**SPECIAL CONDITIONS OF SERVICE :**

1. The customer will sign a contract agreeing to terms and conditions specified for small power producers. The minimum term of the contract is 12 months.
2. If the qualifying facility does not meet the 65% on-peak capacity requirement in any month, the compensation will be the energy portion only.

**REGULATIONS:** General Rules and Regulations govern use under this schedule.

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**SMALL POWER PRODUCER RIDER  
TIME-OF-DAY PURCHASE RATES (Continued)**

**DEFINITIONS:**

Firm Power: Power delivered at a minimum of 65% capacity factor during the on-peak period in each month.

Capacity Factor: The number of kilowatthours delivered during a period divided by the product of (the maximum one hour delivered capacity in kilowatts in the period) times (the number of hours in the period).

Summer On-Peak: May 1 through October 31 including those hours from 8:00 a.m. to 10:00 p.m. Monday through Friday, excluding holidays.

Winter On-Peak: November 1 through April 30 including those hours from 7:00 a.m. to 10:00 p.m. Monday through Friday, excluding holidays.

Holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day.

**TERMS AND CONDITIONS:**

The use of this rate requires that special precautions be taken in the design of associated metering and control systems. The following terms and conditions describe these precautions and shall be followed on all customer-owned small qualifying facilities (SQF).

1. The customer will be compensated monthly for all energy received from the SQF less the metering charge. The schedule for these payments is subject to annual review.
2. If the SQF is located at a site outside of the Company's service territory and energy is delivered to the Company through facilities owned by another utility, energy payments will be adjusted downward reflecting losses occurring between the point of metering and the point of delivery.

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**SMALL POWER PRODUCER RIDER  
TIME-OF-DAY PURCHASE RATES (Continued)**

**TERMS AND CONDITIONS: (Continued)**

3. A SQF must have a generation capacity of at least 30 kW to qualify for wheeling by the Company of the SQF output. In the event that the SQF desires, and qualifies for, wheeling by the Company of the SQF output, arrangements will be made subject to special provisions to be determined by all utilities involved. This also applies to SQF's outside the Company's service territory.
4. A separate meter will be furnished, owned and maintained by the Company to measure the energy to the Company.
5. The SQF shall make provision for on-site metering. All energy received from and delivered to the Company shall be separately metered. On-site use of the SQF output shall be unmetered for purposes of compensation.
6. The customer shall pay for any increased capacity of the distribution equipment serving him and made necessary by the installation of his generator.
7. Power and energy purchased by the SQF from the Company shall be under the available retail rates for the purchase of electricity.
8. The customer's 60 hertz generator output must be at the voltage and phase relationship of the existing service or of one mutually agreeable to the Company and the customer.
9. The customer will provide equipment to maintain a 100% power factor (+ or - 10%) during periods of generator operation.
10. The Company reserves the right to disconnect the customer's generator from its system if it interferes with the operation of the Company's equipment or with the equipment of other company customers.

**SMALL POWER PRODUCER RIDER  
TIME-OF-DAY PURCHASE RATES (Continued)**

**TERMS AND CONDITIONS: (Continued)**

11. Prior to installation, a detailed electrical diagram of the generator and related equipment must be furnished to the Company for its approval for connection to the Company's system. No warranties, express or implied, will be made as to the safety or fitness of the said equipment by the Company due to this approval.
12. The customer shall execute an electric service contract with the Company which may include, among other provisions, a minimum term of service.
13. Equipment shall be provided by the customer that provides a positive means of preventing feedback to the Company during an outage or interruption of that system.
14. The customer shall install, own and maintain all equipment deemed necessary by the Company to assure proper parallel operation of the system.

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# Appendix H Interconnection Requirements

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## H-5. EXAMPLE OF A NET METERING PROGRAM AND TARIFF

PSC No: 120 – Electricity  
New York State Electric and Gas Corporation  
Initial Effective Date: December 1, 2003

Leaf No. 1  
Revision: 0  
Superseding Revision:

**P.S.C. No. 120 - ELECTRICITY  
SUPERSEDING P.S.C. NO. 115**

**NEW YORK STATE GAS AND ELECTRIC CORPORATION  
RULES, REGULATIONS AND GENERAL INFORMATION**

**SCHEDULE  
FOR  
ELECTRIC SERVICE**

**Applicable  
In  
All territory served by this Corporation and  
In all rate schedules except as otherwise  
Provided in individual rate schedules**

## GENERAL INFORMATION

### 22. Farm Waste Electric Generating System Option

Applicable to any customer who owns or operates farm waste electric generating equipment ("Facility"), that generates electric energy from biogas produced by the anaerobic digestion of agricultural wastes with a rated capacity of not more than four hundred kilowatts (400 kW), located and used at his or her "farm operation" as defined in Subdivision 11 of Section 301 of the Agriculture and Markets Law. Such definition states that a "farm operation" means the land and on-farm buildings, equipment, manure processing and handling facilities, and practices which contribute to the production, preparation and marketing of crops, livestock and livestock products as a commercial enterprise, including a "commercial horse boarding operation" as defined in subdivision thirteen of this Section 301 of the Agriculture and Markets Law.

The Facility must be manufactured, installed and operated in accordance with applicable government and industry standards. Such Facility must be connected to NYSEG's electric system and operated in parallel with NYSEG's transmission and distribution facilities. The Facility must be fueled, at a minimum of 90% on an annual basis, by biogas produced from the anaerobic digestion of agricultural waste such as livestock manure materials, crop residues and food processing waste. The Facility must be fueled by biogas generated by anaerobic digestion with at least 75% by weight of its feedstock being livestock manure materials on an annual basis. The customer, at its expense, shall promptly provide to NYSEG all relevant, accurate and complete information, documents, and data, as may be reasonably requested by NYSEG, to enable NYSEG to determine whether the customer is in compliance with these requirements.

The Farm Waste Electric Generating System Option will be available to eligible customers, on a first come, first served basis, until the total rated generating capacity for farm waste electric generating equipment owned or operated by customer-generators in NYSEG's service area is equivalent to 9,912 kW (four-tenths percent of NYSEG's electric demand for the year 1996).

Customers electing service under this Section 22 must operate in compliance with standards and requirements set forth in the Distributed Generation Interconnection Requirements found in PSC 119 - Electricity, Section 9. In addition, customers must execute the NYS Standardized Contract For Interconnection of New Distributed Generation Units With Capacity of 300 kVA or Less, or Farm Waste Generators of 400 kW of Less, to be Operated in Parallel ("SIR Contract"), as contained in PSC 119 - Electricity, Section 9.F.V.

For time-differentiated and demand-billed customers or customers requesting two meters, NYSEG will install (a) an appropriate meter for the customer's service classification to measure the electricity delivered to the customer (the "Billing Meter"), and (b) a non-demand, non-time differentiated meter to measure the electricity generated by the Facility ("Credit Meter"). For each billing period during

the term of the Standard Contract for Farm Waste Electric Generating Systems, NYSEG will determine the billing units (kWh) registered on the Billing Meter (the "Billing Meter Units" or "BMU") for the billing period and the units (kWh) registered on the Credit Meter (the "Credit Meter Units" or "CMU") or the billing period, and NYSEG will compare and net such amounts. If the customer's Billing Meter records delivery on time-differentiated periods (TOU meter), e.g., On-Peak/Off-Peak or Day/Night, this meter arrangement will require the allocation of the CMU to the appropriate Billing Meter time-periods. This allocation will be done according to allocation factors as set forth in a Special Provision provided in each service classification in this Schedule. In lieu of using the Special Provision allocation factors, a customer with a TOU Billing Meter has the option of purchasing, at its expense, a TOU meter as the Credit Meter for the purpose of recording Peak and Off-Peak or Day and Night kWh production for netting against the appropriate Billing Meter time-period kWh usage.

## GENERAL INFORMATION

### 22. Farm Waste Electric Generating System Option (Cont'd.)

For any time-differentiated period within the current billing period, if the allocated CMU exceeds the BMU kWhs for the same time-differentiated period (i.e.,  $CMU > BMU$ ), the residual CMU kWhs will be added to a tracking account (the "Credit Account") and carried over to a future billing period. For demand-billed customers, prior to adding residual CMU kWhs to the Credit Account, any residual CMU kWhs will be converted to a dollar value using the applicable tariff per kWh rate and applied as a credit to the current utility bill Customer Charge and Demand Charge. If the dollar value of the residual CMU kWh exceeds the current Customer Charge and Demand Charge, any remaining dollars will be converted back to kWhs and added to the Credit Account and carried over for a future billing period. Likewise, for any time-differentiated period within the current billing period, if the allocated CMU is less than the BMU (i.e.,  $CMU < BMU$ ), then NYSEG will reduce any units in the Credit Account by the BMU residual units. If the BMU residual units exceed the Credit Account, NYSEG will bill the customer for the net of the BMU and CMU units at the customer's applicable tariff rate and the Credit Account will be reset to zero.

Customers taking service under a non-time-differentiated, non-demand-billed meter may choose to have usage and generation measured through one standard, single energy meter. For non-time-differentiated, non-demand-billed customers that choose to have usage and generation measured through one, standard single energy meter, any excess customer generation will be added to a Credit Account and carried over for a future billing period. Similarly, for a non-time-differentiated, non-demand-billed customers that request service under this option using two meters, any excess customer generation will be added to the Credit Account and carried forward to a future billing period for appropriate netting. The Customer Charge is not impacted by any excess amount in the Credit Account.

If, (a) on an annual basis, during the term of the SIR Contract or (b) on the date the SIR Contract is terminated pursuant to the terms and conditions of said Contract, there exists a positive (kWh) balance in the Credit Account, then NYSEG will issue the customer a cash payment. The payment shall be for an amount equal to the product of the positive Credit Account (kWh) balance times NYSEG's average avoided cost for energy over the most recent 12-month period. The balance in the Credit Account shall be reset to zero once NYSEG makes the cash payment. Upon NYSEG's determination that the customer has taken service under this Section 22 while in violation of the conditions of service set forth in General Information Section 22 of this Schedule, the customer shall forfeit any positive balance accrued in its Credit Account during the annual period in which the violation occurred.

In the event that NYSEG determines that it is necessary to install a dedicated transformer or transformers to protect the safety and adequacy of electric service provided to other customers, the customer shall pay NYSEG's actual costs of purchasing and installing such transformer(s) located and used at customer's "farm operation," in an amount not to exceed three thousand dollars (\$3,000) per "farm operation."

## SERVICE CLASSIFICATION NO. 3

### APPLICABLE TO THE USE OF SERVICE FOR:

Primary Service for any customer with a demand of 25 kilowatts or more but less than 500 kilowatts.

### CHARACTER OF SERVICE:

Continuous - Alternating Current, 60 Cycle;  
Primary (Distribution) Service at 2,400, 4,160, 4,800, 7,200, 8,320, 12,000, 12,470, 13,200, 34,500  
(Regulated) Volts; Subtransmission Service at 34,500 or 46,000 (Both Non-Regulated) Volts; or 34,500  
(Regulated) Volts for "Grandfathered Customers" only; (see Special Provisions (a));  
Single or Three Phase. (Characteristics depend upon available circuits and equipment.)

### RATE CHOICES AVAILABLE TO CUSTOMERS:

Pursuant to NYSEG's Electric Rate Plan and Customer Advantage Program, General Information Section 12 of this Schedule, customers served under this Service Classification will choose from four different electric rate choices offered by the Company as described below. NYSEG will offer two Retail Access rate choices and two Non-Retail Access rate choices.

The two Retail Access choices (1 and 2 below) consist of the Competitive Supplier Price (also known as the ESCO Rate Option ["ERO"] in the Electric Rate Plan), and the NYSEG Fixed Price with Supply Credit (also known as the Bundled Rate Option with Retail Access ["BRO w/RAC"] in the Electric Rate Plan). The two Non-Retail Access choices (3 and 4 below) include the NYSEG Fixed Price (also known as the Bundled Rate Option ["BRO"]), and the NYSEG Variable Price (also known as the Variable Rate Option ["VRO"]).

***NYSEG will provide Delivery Service only for the two Retail Access choices. Commodity Service will be provided by an Energy Services Company (ESCO).***

#### 1. Competitive Supplier Price (ERO)

This Retail Access choice includes a fixed component for NYSEG delivery service, which reflects a credit of \$0.002 per kWh, and a fluctuating Transition Charge (Non-Bypassable Wires Charge ["NBWC"]) described in this section. Pursuant to the Electric Rate Plan, the \$0.002 per kWh credit will apply unless and until replaced by the Commission in the Unbundling Track, Case No. 00-M-0504.

SERVICE CLASSIFICATION NO. 3 (Continued)

**RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

**Competitive Supplier Price (ERO) (cont'd.)**

RATE: (Per Meter, Per Month)

Delivery Service:

	Primary Voltage	Subtransmission Voltage
<b>Customer Charge</b>	\$35.00	\$200.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$4.23
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)		
Up to and including 200 hours use of metered demand	\$0.00255	\$0.00206
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00210	\$0.00165
Over 350 hours use of metered demand	\$0.00128	\$0.00092
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

Transition Charge (Non-Bypassable Wires Charge ["NBWC"]):

All customers served under this Service Classification, taking service under the Competitive Supplier Price (ERO) rate or the NYSEG Variable Price (VRO) rate (see Rate Choice No. 4) will be required to pay a Transition Charge, also known as the Non-Bypassable Wires Charge [NBWC] in the Electric Rate Plan, with the following exception:

The Transition Charge will not apply to all Power For Jobs (PFJ) customer allocations and Economic Development Power (EDP) deliveries up to the MW levels delivered as of February 28, 2003, as specified in General Information Section 10 of this Schedule, Economic Development Power. EDP

deliveries exceeding the above-referenced February 28, 2003 delivery levels will be delivered at the Competitive Supplier Price (ERO) rate, which is subject to the Transition Charge.

The Transition Charge (NBWC) is a per kilowatt-hour charge calculated by summing the above-market costs and below-market benefits of the Company's existing power purchase obligations. The charge includes the difference between (a) the market value of electricity from NYSEG-owned hydroelectric plants, Non-Utility Generators ("NUGs"), and Nine Mile Point 2, and b) contract payments for that electricity. The Transition Charge (NBWC) also includes costs associated with moving electricity through the transmission and distribution systems and the benefits of existing transmission contracts. Additionally, the Transition Charge (NBWC) includes ancillary service costs as well as NYPA Transmission Access Charges ("NTAC").

For customers taking service under the Competitive Supplier Price (ERO) rate or the NYSEG Variable Price (VRO) rate, the Transition Charge (NBWC) may vary monthly, depending on the market prices of electricity. For such customers whose service is electrically connected East of the NYISO Total East Interface, the Transition Charge (NBWC) will include a credit to reflect the higher cost to serve load in that area.

A Transition Charge (NBWC) Statement setting forth the monthly Transition Charge (NBWC) will be filed with the Public Service Commission on not less than three (3) days' notice from the effective date of the revised charge for the first day of the billing cycle each month. Such statement can be found at the end of this Schedule (PSC 120 - Electricity).

## **2. NYSEG Fixed Price with Supply Credit (BRO w/RAC)**

This Retail Access choice provides a Retail Access Credit ("RAC") applied to the NYSEG Fixed Price Choice ("BRO"). This BRO rate can be found in the description for Rate Choice No. 3, the NYSEG Fixed Price, in this Service Classification. The RAC, further described below, fluctuates with the market price of electricity, and consists of energy, Energy Losses (which include Unaccounted For Energy); Unforced Capacity ("UCAP"), UCAP Losses, UCAP Reserves, and an Additional Component of \$0.003 per kWh.

### **Retail Access Credit (RAC)**

The RAC consists of three components:

a) **Energy Component**: For each day of the customer's billing cycle, a daily average value of market supply is derived from the day ahead NYISO posted Locational Based Marginal Prices (LBMP) of electricity for the region (East or West of the NYISO Total East Interface) in which the customer is located, weighted to reflect hourly usage based on load studies for the calendar month and day-type (Weekday, Saturday or Sunday/Holiday) for Service Classification No. 3. LBMP in Zone C will be used for customers electrically connected West of the Total East NYISO Interface. LBMP in Zone G will be used for customers electrically connected East of the NYISO Total East Interface. The daily load weighted market price of energy will be adjusted to reflect losses and Unaccounted For Energy.

SERVICE CLASSIFICATION NO. 3 (Continued)

**RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

These daily average market supply values are used in conjunction with the service classification daily load study usage data to develop a weighted average value of market supply for the customer's specific billing period. The weighted average value of market supply is multiplied by the customer's metered kWh usage to determine the value of market supply to be credited to the customer's bill.

b) Capacity Component: The RAC also includes a component for the value of Unforced Capacity (UCAP), defined as the market-clearing price of capacity in \$/kWh as determined from the NYISO's monthly capacity auction price. The Capacity Component will be revised in accordance with each monthly UCAP auction held by the NYISO. The capacity price will also include UCAP Reserves, and will then be adjusted for UCAP Losses.

c) Additional Component: An additional credit ("Adder") in the amount of \$0.003 per kWh.

Large Commercial Farm Customers taking service under this Service Classification who were participating in the Pilot as of March 31, 2001, are eligible to elect an Adder in the amount of \$0.004. A Commercial Farm Pilot customer who returns to NYSEG bundled service after March 31, 2001 will not be eligible for this farm Pilot adder if such customer later elects to participate in Retail Access. In that event, such customer will receive an adder of \$0.003 per kWh.

***NYSEG will provide Delivery and Commodity Service for the two Non-Retail Access choices.***

SERVICE CLASSIFICATION NO. 3 (Continued)

**RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

**3. NYSEG Fixed Price (BRO)**

This Non-Retail Access choice consists of a bundled price which includes components for the following: fixed NYSEG delivery service, a fixed Transition Charge (Non-Bypassable Wires Charge [NBWC]), and a fixed commodity charge for electricity supplied by NYSEG.

RATE: (Per Meter, Per Month)

Bundled Service

PRIMARY VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$35.00	\$35.00	\$35.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$5.10	\$5.10
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.07380	\$0.08571	\$0.08022
	\$0.07335	\$0.08526	\$0.07977
Over 200 hours use and up to and including 350 hours use of metered demand			
	\$0.07253	\$0.08444	\$0.07895
Over 350 hours use of metered demand			
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

SERVICE CLASSIFICATION NO. 3 (Continued)

**RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

**3. NYSEG Fixed Price (BRO) (Cont'd.)**

RATE: (Per Meter, Per Month)

Bundled Service

SUBTRANSMISSION VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$200.00	\$200.00	\$200.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$4.23	\$4.23	\$4.23
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.07521	\$0.08752	\$0.08095
	\$0.07480	\$0.08711	\$0.08054
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.07407	\$0.08638	\$0.07981
Over 350 hours use of metered demand			
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

\* The rate for NYSEG's Fixed Price (BRO) may be revised every six months on April 1 and October 1 of each year to reflect increases in the cost of providing fixed commodity service. The revised rate will be calculated using the methodology approved by the Commission in Case 01-E-0359 for calculating the commodity portion of BRO prices. Such revised rate will be utilized only if greater than the initial BRO rate effective January 1, 2003. However, the revised rate will be applicable only to a customer who chooses or is placed on the NYSEG Fixed Price (BRO) rate or the NYSEG Fixed Price with Supply Credit (BRO w/RAC) rate, on or after the effective date of the revision. The revised rate remains in effect for such customers through December 31, 2004, regardless of whether the customer chooses the BRO rate or BRO w/ RAC rate.

NYSEG will file such revised BRO rates with the Public Service Commission not less than three days prior to the effective date of the revised rate.

# SERVICE CLASSIFICATION NO. 3 (Continued)

## RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)

### 4. NYSEG Variable Price (VRO)

This Non-Retail Access choice includes a fixed component for NYSEG delivery service, a fluctuating Transition Charge (Non-Bypassable Wires Charge ["NBWC"]) and a commodity charge for electricity supplied by NYSEG which fluctuates with the market price of electricity.

RATE: (Per Meter, Per Month)

#### Delivery Service:

	Primary Voltage	Subtransmission Voltage
<b>Customer Charge</b>	\$35.00	\$200.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$4.23
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)		
Up to and including 200 hours use of metered demand	\$0.00455	\$0.00406
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00410	\$0.00365
Over 350 hours use of metered demand	\$0.00328	\$0.00292
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

## SERVICE CLASSIFICATION NO. 3 (Continued)

### **RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

#### Transition Charge (Non-Bypassable Wires Charge ["NBWC"]):

All customers served under this Service Classification, taking service under the NYSEG Variable Price (VRO) rate will be required to pay a Transition Charge (NBWC), as further described under Rate Choice No. 1, Competitive Supplier Price (ERO).

#### Commodity Service

The charge for Electric Power Supply provided by NYSEG will fluctuate with the market price of electricity and will include the following components: energy, Energy Losses (which include Unaccounted For Energy), Unforced Capacity (UCAP), UCAP Reserves, and UCAP Losses. This charge is determined using the same methodology as described above in this Service Classification under the detailed explanation of the Retail Access Credit (applied to the NYSEG Fixed Price with Supply Credit, Rate Choice No. 2); items "a" (Energy) and "b" (Capacity).

In the event that NYSEG determines that it will incur an estimated gain or loss because purchases for VRO customers were made in the real-time market at prices differing from those in the day-ahead market, NYSEG will credit or recover the full amount of the estimated gain or loss through the non-bypassable wires charge from VRO customers.

#### **MINIMUM CHARGE:**

The minimum charge for service under this Service Classification is the Customer Charge as listed above, or as otherwise stated in the applicable special provisions.

The minimum charge for customers who choose to take all or part of their back-up or maintenance service under this service classification rather than under NYSEG's Service Classification No. 11 is described in the "DETERMINATION OF DEMAND" section.

#### **SURCHARGE TO COLLECT SYSTEM BENEFITS CHARGE ("SBC"):**

A surcharge of \$.0015 per kWh will be added to each Energy Charge on the customers' bills in this Service Classification to collect the System Benefits Charge (as explained in this Schedule, General Information Section 4).

This charge will be effective with usage beginning January 1, 2003.

## SERVICE CLASSIFICATION NO. 3 (Continued)

### **RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

#### **COMPETITIVE METERING OPTION:**

Qualified Customers who select the Competitive Metering Option must comply with the requirements specified in PSC 119 - Electricity and specified in General Information Section 14 of this Schedule, and will receive a Competitive Metering Credit as set forth in Section 2 of Addendum-MET of PSC 119, or superseding issues thereof.

#### **METER OWNED BY CUSTOMER, INSTALLED AND MAINTAINED BY THE CORPORATION:**

Customers electing to own their own meters, as described in Section 3.A.2 of PSC 119 - Electricity, will receive a Meter Ownership Credit as described in Section 3.A.2.a.i of that Schedule. This provision is separate and distinct from Competitive Metering.

Customers participating in Competitive Metering will not receive a Meter Ownership Credit in addition to the existing Competitive Metering Credit provided to such customers.

#### **INCREASE IN RATES AND CHARGES:**

The rates and charges under this Service Classification, including minimum charges, will be increased by a surcharge pursuant to Section 6 of PSC No. 120 to reflect the tax rates applicable within the municipality where the customer takes service.

#### **DETERMINATION OF DEMAND:**

The billing demand will be the metered demand, which is the highest average kilowatts used in a fifteen-minute interval during the month.

For subtransmission customers also served by the Corporation under Special Provision F of Service Classification No. 10, the measured demand of the output provided by the customer's generating facility will be added to the measured demand as determined by the Corporation's meter for service under this Classification.

Customers who choose to take all or part of their back-up or maintenance service under this service classification rather than under NYSEG's Service Classification No. 11 will pay a minimum demand charge as described in NYSEG's Service Classification No. 11. Customers will pay a minimum demand charge related to generation, ancillary, and transmission costs. The minimum demand charge is based on a rate per kW of the contract demand and is accumulated over a 12-month period. The accumulated contract demand charge component will be compared to the accumulated demand charge in this service classification. If the contract demand charge is greater than the demand charge in this service classification, then the customer will only pay the contract demand charge in that month. If it is less than the demand charge in this service classification, then the customer will pay that difference in that month.

SERVICE CLASSIFICATION NO. 3 (Continued)

**RATE CHOICES AVAILABLE TO CUSTOMERS: (CONT'D.)**

**DETERMINATION OF REACTIVE KILOVOLT-AMPERE HOURS:**

Whenever the customer's metered demand is 200 kW or more for two consecutive billing periods, the reactive kilovolt-ampere hours shall thereafter be metered. The billing reactive kilovolt-ampere hours shall be the reactive kilovolt-ampere hours in excess of one-third of the metered kilowatt hours.

**TERMS OF PAYMENT:**

All bills are rendered at the above "unit prices" and that amount is due on bills paid on or before the "past due" date indicated on the bill. A late payment charge at the rate of one and one-half percent (1 1/2%) per month will be billed on all amounts not paid by that date. (Further details in Section 4 of P.S.C. No. 119 - Electricity or superseding issues thereof.)

**TERM:**

One year and thereafter until terminated by 30 days' written notice. However, the Corporation may, with the permission of the Public Service Commission, require the customer to agree to take service at rates from time to time effective for a longer term dependent upon the amount of investment required or other unusual conditions incident to the service.

**SPECIAL PROVISIONS:**

**(a) Primary Discounts:**

The above subtransmission rates reflect a discount for a customer who furnishes and maintains the necessary substation and purchases energy at 34,500 or 46,000 (both Non-Regulated) Volts.

Customers receiving service prior to February 15, 2000 ("Grandfathered Customers"), will receive the stated Primary Discounts when the customer furnishes and maintains the necessary substation and purchases energy at 34,500 (Regulated).

**(b) Balanced Billing:**

Customers may, by signing an application, be billed monthly in accordance with the plan set forth in Section 4-0 of P.S.C. No. 119 - Electricity or superseding issues thereof.

**(c) Submetering:**

Submetering may be available according to certain conditions as explained in the general information leaves of this schedule, Section 2. Submetering.

## SERVICE CLASSIFICATION NO. 3 (Continued)

### **SPECIAL PROVISIONS: (Cont'd)**

#### (d) Economic Incentives:

Customer load supplied by the New York Power Authority (NYPA) is not eligible to receive an economic incentive.

##### (1) Economic Revitalization Incentive:

Customers who qualify under the Economic Revitalization Incentive (ERI) in Section 7 of the General Information section of this Schedule shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for the qualified incented load.

Such customers will have their service bills reduced, for a term of 36 months, by an incentive rate of \$.01 per kilowatt-hour for all qualified kilowatt-hours used thereunder. For two subsequent 12-month phase-out terms, the incentive rate will be multiplied by .66 and .33 for each term, respectively.

##### (2) Economic Development Incentive:

Customers who qualify, under the Economic Development Incentive (EDI) in Section 8 of the General Information section of this Schedule, to receive an incentive for load qualified prior to July 1, 2003 shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this service classification and Section 12, Customer Advantage Program, of this Schedule, for the qualified incented load.

Such customers will have their service bills reduced, for a term of 60 months, by an incentive rate of \$.015 per kilowatt-hour for all qualified kilowatt-hours used thereunder.

Customers who qualify, under the Economic Development Incentive (EDI) in Section 8 of the General Information section of this Schedule, to receive an incentive for load qualified on or after July 1, 2003 may select one of the following rate options, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for such qualified incented load: 1) NYSEG Fixed Price (BRO), 2) NYSEG Variable Price (VRO), or 3) Competitive Supplier Price (ERO).

Such customers will have their service bills reduced, for a term of 60 months, by an incentive rate per kilowatt-hour for all qualified kilowatt-hours used thereunder. The incentive rate will be the lesser of: a) \$.015 or b) the equivalent of the applicable Transition Charge (NBWC), as specified in this Service Classification, less the ancillary service costs and NYPA Transmission Access Charges (NTAC) components of the Transition Charge.

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd)**

(d) Economic Incentives: (Cont'd)

(2) Economic Development Incentive: (Cont'd.)

The incentive rate for such qualified load billed at ERO or VRO may change monthly due to the fluctuating Transition Charge. An Economic Incentive Rate (EIR) Statement setting forth the monthly incentive rates for each rate option will be filed with the Public Service Commission on not less than three (3) days' notice prior to the first day of each month. Such statement can be found at the end of this Schedule (PSC 120 - Electricity).

(3) Economic Development Zone Incentive:

Customers who qualify, under the Economic Development Zone Incentive (EDZI) in Section 9 of the General Information section of this Schedule, to receive an incentive for load qualified prior to July 1, 2003 shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for the qualified incented load.

Such customers will have their service bills reduced, for a term of ten (10) years beginning on the date of the qualifying load installation and operation (unless the customer's initial zone certification(s) becomes invalid), by the following incentive rate per kilowatt-hour for all qualified kilowatt-hours used thereunder.

Rate for qualified kilowatt-hours, per kWh in existing economic development zones designated prior to October 9, 1997:

For EDZI qualifications prior to Aug. 1, 1994	\$ .020
For EDZI qualifications on or after Aug. 1, 1994	.025
For EDZI qualifications on or after Mar. 3, 1998	.040

Rate for qualified kilowatt-hours, per kWh in all zones designated after October 9, 1997 and on or before February 1, 1999:

For EDZI load qualifications on or after March 3, 1998 in the next two zones designated	\$ .040
For EDZI load qualifications on or after March 3, 1998 in any additional zones designated	\$ .0325
For EDZI load qualifications on or after March 3, 2000	\$ .040

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd)**

(d) Economic Incentives: (Cont'd)

(3) Economic Development Zone Incentive: (Cont'd.)

Rate for qualified kilowatt-hours, per kWh in any zones designated after February 1, 1999:

For EDZI Load qualifications on or after March 3, 2000	\$ .0325
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Customers who qualify, under the Economic Development Zone Incentive (EDZI) in Section 9 of the General Information section of this Schedule, to receive an incentive for load qualified on or after July 1, 2003 may select one of the following rate options, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for such qualified incented load: 1) NYSEG Fixed Price (BRO), 2) NYSEG Variable Price (VRO), or 3) Competitive Supplier Price (ERO).

Such customers will have their service bills reduced, for a term of ten (10) years following initial zone certification, beginning with the eligibility date on the zone certificate (unless the customer's initial zone certification(s) becomes invalid), by an incentive rate per kilowatt-hour for all qualified kilowatt-hours used thereunder. The incentive rate will be the equivalent of the applicable Transition Charge (NBWC), as described in this Service Classification, less the ancillary service costs and NTAC components of the Transition Charge.

The incentive rate for such qualified load billed at ERO or VRO may change monthly due to the fluctuating Transition Charge. An Economic Incentive Rate (EIR) Statement setting forth the monthly incentive rates for each rate option will be filed with the Public Service Commission on not less than three (3) days' notice prior to the first day of each month. Such statement can be found at the end of this Schedule (PSC 120 - Electricity).

**SPECIAL PROVISIONS: (Cont'd)****(d) Economic Incentives: (Cont'd)****(3) Economic Development Zone Incentive: (Cont'd.)**

The qualified incented load will be billed at the following applicable BRO, VRO, or ERO rates:

NYSEG Fixed Price (BRO)\*:

PRIMARY VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$35.00	\$35.00	\$35.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$5.10	\$5.10
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.07380	\$0.08571	\$0.08022
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.07335	\$0.08526	\$0.07977
Over 350 hours use of metered demand	\$0.07253	\$0.08444	\$0.07895
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

\* These rates may be revised every six months on April 1 and October 1 of each year, as explained in Rate Choices Available to Customers, NYSEG Fixed Price (BRO), in this Service Classification.

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(d) Economic Incentives: (Cont'd)

(3) Economic Development Zone Incentive: (Cont'd.)

NYSEG Fixed Price (BRO)\*: (Cont'd)

SUBTRANSMISSION VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$119.01	\$119.01	\$119.01
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$2.52	\$2.52	\$2.52
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.07357	\$0.08588	\$0.07931
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.07332	\$0.08563	\$0.07906
Over 350 hours use of metered demand	\$0.07289	\$0.08520	\$0.07863
<b>Reactive Charge</b>			
Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

\* These rates may be revised every six months on April 1 and October 1 of each year, as explained in Rate Choices Available to Customers, NYSEG Fixed Price (BRO), in this Service Classification.

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(d) Economic Incentives: (Cont'd)

(3) Economic Development Zone Incentive: (Cont'd.)

NYSEG Variable Price (VRO):

	Primary Voltage	Subtransmission Voltage
<b>Customer Charge</b>	\$35.00	\$119.01
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$2.52
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)		
Up to and including 200 hours use of metered demand	\$0.00455	\$0.00242
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00410	\$0.00217
Over 350 hours use of metered demand	\$0.00328	\$0.00174
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd)**

(d) Economic Incentives: (Cont'd)

(3) Economic Development Zone Incentive: (Cont'd.)

Competitive Supplier Price (ERO):

	Primary Voltage	Subtransmission Voltage
<b>Customer Charge</b>	\$35.00	\$119.01
<b>Demand Charge</b> (All kilowatts, per kilowatt)	\$5.10	\$2.52
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)		
Up to and including 200 hours use of metered demand	\$0.00255	\$0.00242
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00210	\$0.00217
Over 350 hours use of metered demand	\$0.00128	\$0.00174
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

(4) Economic Development Power:

Customers who qualify for the special Economic Development Power rate provision pursuant to Section 10 of the General Information Section of this Schedule, will have such power billed in accordance with the Special Provision therein. The customer's power requirements in excess of the Economic Development Power will be billed at SC No. 7 rates applicable to the customer's voltage level.

(5) Self-Generation Deferral Incentive ("SGDI"):

Customers who qualify for the Self-Generation Deferral Incentive (SGDI) under Section 11 of the General Information section of this Schedule shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule.

Such customers will have their service bills subject to a cents per kilowatt-hour price cap in accordance with the SC No. 7 Special Provision (d)(6), Self-Generation Deferral Incentive.

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(d) Economic Incentives: (Cont'd)

(6) Incubator Development Incentive ("IDI"):

Customers who qualify under the Incubator Development Incentive (IDI) in Section 13 of the General Information section of this Schedule prior to July 1, 2003 shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for the qualified incented load.

Such customers will have their service bills reduced by an incentive rate of \$.025 per kilowatt-hour for all qualified kilowatt hours thereunder.

Customers who qualify under the Incubator Development Incentive (IDI) in Section 13 of the General Information section of this Schedule on or after July 1, 2003 may select the applicable NYSEG Fixed Price (BRO) or the NYSEG Fixed Price with Supply Credit (BRO w/RAC) for the qualified incented load.

Such customers will have their service bills reduced by an incentive rate of \$.0186 per kilowatt-hour for all qualified kilowatt-hours used thereunder.

Effective January 1, 2005, this incentive rate will be revised to be equivalent to the applicable Transition Charge, less the ancillary service costs and NTAC components, associated with the NYSEG Fixed Price (BRO) rates established for the second commodity offering period, per the Company's Electric Rate Plan.

Under the BRO w/RAC, the market-based backout will not include the Additional Component as described in this Service Classification and General Information Section 16.D., General Retail Access, of this Schedule.

(7) Business Retention Incentive:

This provision expired on March 2, 2003. Any customers who were receiving the BRI discount as of that date may transition to the Economic Revitalization Incentive (ERI), as described in General Information Section 7 of this Schedule, for the remainder of their five-year term.

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(d) Economic Incentives: (Cont'd)

The transition will be based on the start date of their BRI discount, and the following incentive rate reductions will apply:

- A customer in the first, second, or third year of BRI would receive the full ERI reduction for those years.
- A customer in the fourth year of BRI would receive the ERI reduction multiplied by a factor of .66 for that year.
- A customer in the fifth (and final) year of BRI would receive the ERI reduction multiplied by a factor of .33 for that year.

(8) Small Business Growth Incentive ("SBGI"):

Customers who qualify under the Small Business Growth Incentive (SBGI) in Section 19 of the General Information section of this Schedule shall take service under the applicable NYSEG Fixed Price (BRO) rate, as specified in this Service Classification and Section 12, Customer Advantage Program, of this Schedule, for the qualified incented load.

Customers who are qualified for such SBGI prior to July 1, 2003 will have their service bills reduced by an incentive rate of \$.030 per kilowatt-hour, for all qualified kilowatt-hours used thereunder, through December 31, 2003.

Beginning January 1, 2004, the incentive rate will be revised annually, calculated based on the Transition Charge associated with the NYSEG Fixed Price (BRO) rates. Effective January 1, 2004, the incentive rate per kWh for qualified kWhs will be \$.0281. Annual incentive rates thereafter will be determined in conjunction with the BRO rates for the second commodity offering period, pursuant to the Company's Electric Rate Plan.

Customers who are qualified for such SBGI on or after July 1, 2003 will have their service bills reduced by an incentive rate of \$.0225 per kilowatt-hour for all qualified kilowatt-hours used thereunder.

Effective January 1, 2005, the incentive rate will be revised to be equivalent to the applicable Transition Charge associated with the NYSEG Fixed Price (BRO) rates established for the second commodity offering period, per the Company's Electric Rate Plan.

## SERVICE CLASSIFICATION NO. 3 (Continued)

### **SPECIAL PROVISIONS: (Cont'd.)**

(e) Controlled Load Time-of-Use Service Option:

Customers who have a total connected load of at least 25 kW, with at least 12.5 kW of that load being newly installed controlled equipment, may choose to take their entire service under Service Classification No. 7 with Time-of-Use metering. Controlled Load equipment will include, but not be limited to, Electric Thermal Storage equipment (E.T.S.), Air Conditioning equipment, Water Heating or other Heating/Cooling installations which are designed to operate advantageously during off-peak hours as defined in Service Classification No. 7.

(f) RESERVED FOR FUTURE USE

(g) RESERVED FOR FUTURE USE

(h) Industrial/High Load Factor ("I/HLF") Rate Provision:

- (1) Available to a customer's account that meets usage eligibility as defined in (2) or (3) of this section:

Customers who are taking service under NYSEG's Economic Development Incentive, Economic Development Zone Incentive, New York Power Authority (NYPA) programs (Expansion Power, Economic Development Power, and Power For Jobs) or S.C. 14 may take service under this rate provision, only for that portion of their load served at NYSEG's standard tariff rate, provided that the non-discounted load meets the eligibility requirements of this special provision. Allocation of billing units (kW, kWh, rkvh) for partial load is explained in (3) of this section.

Recipients of other NYSEG incentive rates applicable to their entire load, may qualify for this special provision by relinquishing eligibility under the incentive, provided that they meet the eligibility requirements of this special provision.

Any customer taking service under the Economic Revitalization Incentive and, choosing instead to take service under this Rate Provision, must have met or agrees to continue to meet its Economic Revitalization commitments.

- (2) Eligibility:

Eligibility will be determined based on the total metered demand and energy excluding the NYPA portion of that metered amount.

- (i) Industrial Rate Provision:

Not applicable to customers in this service classification. Customers with average annual demands in excess of 500 kW, are served under S.C. No. 7.

## SERVICE CLASSIFICATION NO. 3 (Continued)

### **SPECIAL PROVISIONS: (Cont'd.)**

#### (h) Industrial/High Load Factor Rate Provision: (Cont'd.)

##### (2) Eligibility: (Cont'd.)

##### (ii) High Load Factor Rate Provision:

Applicable to an existing customer's account having an annual load factor of 68.0% or greater (approximately 500 hours' average use of kW demand per month). Also applicable to a new customer's account with an estimated annual load factor of 68.0% or greater. Annual load factor for this provision is calculated as follows:

$$A/(D*H)$$

A = Annual kWh. For existing customers this will be the actual total energy usage billed during the most recent 12 consecutive months. For new customers or customers with incomplete history, the annual usage will be estimated by the Corporation from engineering and operating estimates to fit within the time period.

D = Maximum demand. For existing customers this will be the highest billed demand during the most recent 12 consecutive months. For new customers or customers with incomplete history, the demand will be estimated by the Corporation from engineering and operating estimates to fit within the time period.

H = Number of total hours in the annual billing period.

##### (3) Allocation of Billing Units for Partial Load:

Billing units (kW, kWh, rkvah) will be allocated between the Industrial/High Load Factor and Economic Incentive portions of the customer's bill based on the following formula:

B	= Billing kW
T	= Total kWh
EKWH	= Incented kWh
EKW	= Incented kW
NKW	= Non-incented kW

$$(EKWH / T) \times B = EKW$$

$$B - EKW = NKW$$

## SERVICE CLASSIFICATION NO. 3 (Continued)

### SPECIAL PROVISIONS: (Cont'd.)

(h) Industrial/High Load Factor Rate Provision: (Cont'd.)

(3) Rate Qualification Review:

Each account will be reviewed annually for continued qualification, based on the load factor during the previous year. Such review shall occur 12 months after the initiation of this rate provision, and shall be repeated each year thereafter. To maintain qualification for this rate, a customer account's annual load factor must be 68.0% or greater.

(4) Rate for Qualified High Load Factor Service:

A complete description of these rate choices appears previously in this Service Classification.

(a) Competitive Supplier Price (ERO)

Rates for Delivery Service under the High Load Factor Special Provision are as follows:

<b>RATE: (Per Meter/Per Month)</b>		
	Primary Voltage	Subtransmission Voltage
<b>Customer Charge:</b>	\$35.00	\$200.00
<b>Demand Charge:</b> All kilowatts, per kilowatt		
On-Peak Service	\$1.83	\$1.74
Off-Peak Service	N/A	N/A
<b>Energy Charge:</b> All kilowatt-hours, per kilowatt		
Up to and including 200 hours use of metered demand	\$0.00131	\$0.00014
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00098	\$0.00083
Over 350 hours use of metered demand	\$0.00068	\$0.00055
<b>Reactive Charge:</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

# SERVICE CLASSIFICATION NO. 3 (Continued)

## SPECIAL PROVISIONS: (Cont'd.)

(h) Industrial/High Load Factor Rate Provision: (Cont'd.)

(4) Rate for Qualified High Load Factor Service: (Cont'd.)

(b) NYSEG Fixed Price with Supply Credit (BRO w/RAC) or NYSEG Fixed Price (BRO) Rates for Bundled Service under the High Load Factor Special Provision are as follows:

RATE: (Per Meter/Per Month)

PRIMARY VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$35.00	\$35.00	\$35.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)			
On-Peak Service	\$1.83	\$1.83	\$1.83
Off-Peak Service	N/A	N/A	N/A
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.07003	\$0.08135	\$0.07604
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.06970	\$0.08102	\$0.07571
Over 350 hours use of metered demand	\$0.06940	\$0.08072	\$0.07541
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

\* The rate for NYSEG's Fixed Price (BRO) may be revised every six months on April 1 and October 1 of each year to reflect increases in the cost of providing fixed commodity service. The revised rate will be calculated using the methodology approved by the Commission in Case 01-E-0359 for calculating the commodity portion of BRO prices. Such revised rate will be utilized only if greater than the initial BRO rate effective January 1, 2003. However, the revised rate will be applicable only to a customer who chooses or is placed on the NYSEG Fixed Price (BRO) rate or the NYSEG Fixed Price with Supply Credit (BRO w/RAC) rate, on or after the effective date of the revision. The revised rate remains in effect for such customers through December 31, 2004, regardless of whether the customer chooses the BRO rate or BRO w/ RAC rate.

NYSEG will file such revised BRO rates with the Public Service Commission not less than three days prior to the effective date of the revised rate.

# SERVICE CLASSIFICATION NO. 3 (Continued)

## SPECIAL PROVISIONS: (Cont'd.)

(h) Industrial/High Load Factor Rate Provision: (Cont'd.)

(4) Rate for Qualified High Load Factor Service: (Cont'd.)

(b) NYSEG Fixed Price with Supply Credit (BRO w/RAC) or NYSEG Fixed Price (BRO)  
Rates for Bundled Service under the High Load Factor Special Provision are as follows:

RATE: (Per Meter/Per Month)

SUBTRANSMISSION VOLTAGE	Effective Date*		
	01/01/03	04/01/03	10/01/03
<b>Customer Charge</b>	\$35.00	\$35.00	\$35.00
<b>Demand Charge</b> (All kilowatts, per kilowatt)			
On-Peak Service	\$1.74	\$1.74	\$1.74
Off-Peak Service	N/A	N/A	N/A
<b>Energy Charge</b> (All kilowatt-hours, per kilowatt-hour)			
Up to and including 200 hours use of metered demand	\$0.06986	\$0.08118	\$0.07587
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.06955	\$0.08087	\$0.07556
Over 350 hours use of metered demand	\$0.06927	\$0.08059	\$0.07528
<b>Reactive Charge</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095	\$0.00095

\* The rate for NYSEG's Fixed Price (BRO) may be revised every six months on April 1 and October 1 of each year to reflect increases in the cost of providing fixed commodity service. The revised rate will be calculated using the methodology approved by the Commission in Case 01-E-0359 for calculating the commodity portion of BRO prices. Such revised rate will be utilized only if greater than the initial BRO rate effective January 1, 2003. However, the revised rate will be applicable only to a customer who chooses or is placed on the NYSEG Fixed Price (BRO) rate or the NYSEG Fixed Price with Supply Credit (BRO w/RAC) rate, on or after the effective date of the revision. The revised rate remains in effect for such customers through December 31, 2004, regardless of whether the customer chooses the BRO rate or BRO w/ RAC rate.

NYSEG will file such revised BRO rates with the Public Service Commission not less than three days prior to the effective date of the revised

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(h) Industrial/High Load Factor Rate Provision: (Cont'd.)

(4) Rate for Qualified High Load Factor Service: (Cont'd.)

(c) NYSEG Variable Price (VRO)

Rates for Delivery Service under the High Load Factor Special Provision are as follows:

<b>RATE: (Per Meter/Per Month)</b>		
	Primary Voltage	Subtransmission Voltage
<b>Customer Charge:</b>	\$35.00	\$200.00
<b>Demand Charge:</b> All kilowatts, per kilowatt		
On-Peak Service	\$1.83	\$1.74
Off-Peak Service	N/A	N/A
<b>Energy Charge:</b> All kilowatt-hours, per kilowatt		
Up to and including 200 hours use of metered demand	\$0.00331	\$0.00314
Over 200 hours use and up to and including 350 hours use of metered demand	\$0.00298	\$0.00283
Over 350 hours use of metered demand	\$0.00268	\$0.00255
<b>Reactive Charge:</b> Reactive kilovolt-ampere hours, per billing reactive kilovolt-ampere hour	\$0.00095	\$0.00095

SERVICE CLASSIFICATION NO. 3 (Continued)

**SPECIAL PROVISIONS: (Cont'd.)**

(h) Industrial/High Load Factor Rate Provision: (Cont'd.)

(4) Rate for Qualified High Load Factor Service (Per Month) (Cont'd.)

Primary Discounts:

The above subtransmission rates reflect a discount for a customer who furnishes and maintains the necessary substation and purchases energy at 34,500 or 46,000 (both Non-Regulated) volts. Customers receiving service prior to February 15, 2000 ("Grandfathered Customer"), will receive the stated Primary Discounts when the customer furnishes and maintains the necessary substation and purchases energy at 34,500 (Regulated).

(i) Real Time Pricing ("RTP") Provision:

REAL TIME PRICING:

This RTP provision will provide customers with an opportunity to develop load management programs to better respond to high hourly market prices and take advantage of low hourly market prices. The program will provide experience with interval metering and billing solutions. Customers will be encouraged to modify operations to reduce usage during high priced periods or to shift usage to take advantage of the lower energy costs during certain hours.

ELIGIBILITY:

The Company will solicit commercial, industrial and public authority customers who have the ability to shift loads and benefit from hourly pricing. To participate, customers may not have other incentives, receive NYPA power or participate in retail access. This program is available to customers with load capped at 25 MW in the aggregate. Eligible customers may enroll on a first-come, first served basis. To be eligible, customers must choose the NYSEG Variable Price (VRO) rate option, a complete description of which appears previously in this Service Classification, and in Section 12 of this Schedule, Customer Advantage Program.

ADDITIONAL REQUIREMENTS AND METERING:

Customers shall install all necessary equipment, including, but not limited to, interval metering and required telephone lines. Such metering will be installed, controlled, operated and maintained by the Company at the customer's expense. The Company will provide meters at cost (including materials and labor) to customers who enroll in the RTP Program. The Company may, at the customer's expense, require installation of additional communication equipment, software or a monthly subscription service for the administration of this special provision.

### SERVICE CLASSIFICATION NO. 3 (Continued)

#### SPECIAL PROVISIONS: (Cont'd.)

##### (i) Real Time Pricing ("RTP") Provision: (Cont'd.)

Eligible customers receiving metering from competitive metering providers may participate in this Real Time Pricing Program, using metering equipment and communications capabilities that the Company has determined can provide the necessary hourly interval usage data.

##### CALCULATION OF THE RTP BILL:

Customers are responsible for all charges associated with the NYSEG Variable Price (VRO) rate option as described in this Service Classification, and General Information Section 12 of this Schedule – Customer Advantage Program. Additionally, the VRO Commodity Service will be replaced with the RTP Program Commodity Service, described as follows.

The hourly day-ahead NYISO Locational-Based Marginal Prices ("LBMP") of electricity in Zones C or G (as applicable) will be applied to the customer's interval metered hourly usage. NYSEG will also add Energy Losses (which include Unaccounted For Energy), Unforced Capacity (UCAP), UCAP Reserves, and UCAP Losses to the LBMP determined prices. UCAP is defined as the market-clearing price of capacity in \$/kWh as determined from the NYISO's monthly capacity auction price and the service classification load profile. The Capacity Component will be revised in accordance with each monthly UCAP auction held by the NYISO.

##### TERM AND EVALUATION OF THE PILOT PROGRAM:

The term of service is consistent with the customer choosing the NYSEG Variable Price (VRO) rate option, a complete description of which appears previously in this Service Classification, and in Section 12 of this Schedule, Customer Advantage Program. The Company will work closely with each RTP customer. The Company will evaluate the Program, including costs and benefits and propose necessary changes after each year of the Program.

##### (j) Emergency Demand Response Program ("EDRP"):

The EDRP seeks to provide customers with an economic incentive to respond to Emergency Operating Conditions as identified by the NYISO. EDRP can provide the NYISO, through the Company, with the ability to request voluntary load curtailment or replacement by participating customers for electric usage.

Customers who are qualified under EDRP in Section 20 of the General Information section of this Schedule may participate in the NYSEG EDRP as set forth therein.

SERVICE CLASSIFICATION NO. 3 (Continued)

SPECIAL PROVISIONS: (Cont'd.)

(k) C.A.\$.H.BACK Special Provision:

The Company will provide a voluntary program for load normally supplied and delivered by NYSEG, for eligible customers to curtail load. NYSEG's program, entitled C.A.\$.H.BACK, implements the NYISO's day-ahead economic load-curtailement program. Under this program, a customer agrees to curtail load when their bid is submitted and accepted by the NYISO.

Customers who are qualified under C.A.\$.H.BACK in Section 21 of the General Information section of this Schedule may participate in the NYSEG C.A.\$.H.BACK Program as set forth therein.

(l) Farm Waste Electric Generating System Option:

This option is for a customer qualifying for the Farm Waste Electric Generating System Option pursuant to General Information Section 22 of this Schedule, and taking service under SC 3. The Company will net, as provided for in Section 22:

(1) The kilowatt-hours produced for up to and including the first 200 hours of the measured electricity produced by the customer's Facility as measured on the non-demand, non-time differentiated Credit Meter and at the billed demand on the Billing Meter with that consumed by the customer and billed as kilowatt-hours, per kilowatt for up to and including 200 hours use of metered demand from the Billing Meter.

(2) The kilowatt-hours produced for over 200 hours use and up to and including 350 hours of the measured electricity produced by the customer's Facility as measured on the non-demand, non-time differentiated Credit Meter and at the billed demand on the Billing Meter with that consumed by the customer and billed as kilowatt-hours, per kilowatt for over 200 hours use and up to and including 350 hours use of metered demand from the Billing Meter.

(3) The kilowatt-hours produced for over 350 hours use measured electricity produced by the customer's Facility as measured on the non-demand, non-time differentiated Credit Meter and at the billed demand on the Billing Meter with that consumed by the customer and billed as kilowatt-hours, per kilowatt for over 350 hours use of metered demand from the Billing Meter.

# Appendix I

## Industry Directory for On-Farm Biogas Recovery Systems

This appendix is a reprint of the AgSTAR Program's second edition of the *Industry Directory for On-Farm Biogas Recovery Systems* (released in July 2003). This Directory is designed to help farm owners identify appropriate consultants, project developers, energy service providers, equipment manufacturers and distributors, and commodity organizations. The Directory provides descriptions, relevant experience, and contact information for each business listed. While the best efforts were made to contact domestic and international businesses with relevant experience, the Directory is not exhaustive. AgSTAR will continue to update the Directory as new businesses emerge or existing businesses expand into the livestock waste market. These updates will be posted on the AgSTAR Web site ([www.epa.gov/agstar](http://www.epa.gov/agstar)), where this Directory and other AgSTAR Program products can be downloaded.

The organizations are listed in the following order:

- Commodity Organizations
- Consultants
- Developers
- Equipment Suppliers/Distributors: Covers
- Equipment Suppliers/Distributors: Engines
- Equipment Suppliers/Distributors: System Components
- General Energy Services
- Publishers
- Universities

If you are interested in being included in this Directory, please call the AgSTAR Hotline at 1-800-95 AgSTAR (1-800-952-4782) from 9:00 a.m. to 5:00 p.m. Eastern Standard Time.

EPA does not guarantee the accuracy of the information that has been supplied by the listed organizations. Listing in this Directory does not imply EPA endorsement of any listed organization. All users of this Directory must employ their own due diligence in making decisions based on information found within.

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## Appendix I      Industry Directory for On-Farm Biogas Recovery Systems

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### Commodity Organizations

#### **Dairy Quality Assurance Center**

Keith Carlson	<b>Tel:</b> 515/838-2793		
801 Shakespeare Avenue	<b>Ext:</b>	<b>Email:</b> kcarlson@dqacenter.org	<b># Yrs in Business:</b> 9
Stratford            IA    50249	<b>Fax:</b> 515/838-2788	<b>Web:</b> <a href="http://www.dqacenter.org">www.dqacenter.org</a>	<b># Employees:</b> 3
US			

The Dairy Quality Assurance Center provides national publicity to dairy farmers.

### Consultants

#### **Bioenergy & Environmental, LLC**

Jun Yoshitani	<b>Tel:</b> 630/588-8776		
211 East Illinois Street	<b>Ext:</b>	<b>Email:</b> westoak@ix.netcom.com	<b># Yrs in Business:</b> 7
Wheaton            IL    60187	<b>Fax:</b> 630/588-8779	<b>Web:</b> <a href="http://www.BandE.com">www.BandE.com</a>	<b># Employees:</b> 3
US			

Bioenergy & Environmental, LLC (B&E) offers comprehensive planning, design, and construction services for the implementation of integrated bioenergy and environmental facilities. Through the company's experience working with more than 20 livestock facilities, B&E has developed a systematic, computer-aided approach for helping producers analyze their farm energy potentials and understand their obligations to CAFO rules. B&E incorporates application of phytotechnology for low-cost, on-farm nutrient control systems, and provides assistance in preparing Farm Bill Title IX grant/loan applications.

#### **Bridgestone Associates, Ltd.**

Martin C.T. Anderson	<b>Tel:</b> 610/388-6191		
P.O. Box 1299	<b>Ext:</b>	<b>Email:</b> mcta@brdgstn.com	<b># Yrs in Business:</b> 12
Chadds Ford        PA    19317	<b>Fax:</b> 610/388-0394	<b>Web:</b> <a href="http://www.brdgstn.com">www.brdgstn.com</a>	<b># Employees:</b> 6
US			

Consultants in the evaluation, design, financing, construction, and operations of animal manure anaerobic digestion and other disposal facilities

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## Industry Directory for On-Farm Biogas Recovery Systems

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and other renewable energy projects.

### Dennis Gerber, Consultant

Dennis Gerber  
15870 Rose Avenue  
Los Gatos CA 95030  
US

**Tel:** 408/395-9020

**Ext:**

**Fax:** 408/395-9020

**Email:** [dhgerber@attbi.com](mailto:dhgerber@attbi.com)

**Web:**

**# Yrs in Business:** NA

**# Employees:** NA

Mr. Gerber designs and installs anaerobic digester covers. His Gas Collecting Floating Cover design, which holds a U.S. Patent, is the de-facto standard for flexible membrane anaerobic digesters.

### E3 Ventures

Mike Walker  
1140 Kildaire Farm Road, Suite 304  
Cary NC 27511  
US

**Tel:** 919/469-3737

**Ext:**

**Fax:** 919/469-3656

**Email:** [mwalker@e3ventures.com](mailto:mwalker@e3ventures.com)

**Web:** [www.e3ventures.com](http://www.e3ventures.com)

**# Yrs in Business:** 7

**# Employees:** 4

E3 Ventures provides regulatory consulting related to the Clean Air Act.

### EnviroEnergetics

Sam Ghosh, PhD  
1281 E. Federal Heights Drive  
Salt Lake City UT 84103  
US

**Tel:** 801/596-2166

**Ext:**

**Fax:** 801/596-2166

**Email:** [ghoshsambhunath@hotmail.com](mailto:ghoshsambhunath@hotmail.com)

**Web:**

**# Yrs in Business:** 14

**# Employees:** 5

Established in 1988, EnviroEnergetics provides assistance with anaerobic digestion process development, demonstration, and full-scale application and operation. The company has designed, evaluated, and/or modified prototype or full-scale municipal, industrial, and agricultural digestion systems throughout the United States in California, Illinois, Utah, Florida, and Colorado, and internationally in China and India.

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## Appendix I

## Industry Directory for On-Farm Biogas Recovery Systems

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### Environmental Resource Recovery Group, LLC (EnRRG)

Burt Tribble		<b>Tel:</b> 913/886-8051		
15789 202 Street		<b>Ext:</b>	<b>Email:</b> <a href="mailto:btribble@enrrg.com">btribble@enrrg.com</a>	<b># Yrs in Business:</b> NA
Nortonville	KS 66060	<b>Fax:</b> 775/205-1966	<b>Web:</b> <a href="http://www.enrrg.com">www.enrrg.com</a>	<b># Employees:</b> 10
US				

Environmental Resource Recovery Group (EnRRG) is a recently formed company whose partners have experience in anaerobic digestion and waste-to-energy in agriculture, agribusiness, and the food industry. EnRRG's business is identifying practical energy recovery, anaerobic digestion, and waste management projects, evaluating their economic potentials, and bringing together qualified projects with development partners. Qualified projects are those meeting technical requirements and economic investment guidelines.

### Fraunhofer Center for Energy and Environment

Junchul Kim, Ph.D.		<b>Tel:</b> 412/624-8609		
5940 Baum Square, Suite 7		<b>Ext:</b>	<b>Email:</b> <a href="mailto:jckim@engr.pitt.edu">jckim@engr.pitt.edu</a>	<b># Yrs in Business:</b> 2
Pittsburgh	PA 15206	<b>Fax:</b> 412/624-8860	<b>Web:</b>	<b># Employees:</b> 4
US				

Fraunhofer Center for Energy and Environment was established in 2001 as a non-profit organization. The goal of the Center is to introduce technologies and processes developed and demonstrated by Fraunhofer in Germany into the United States, providing solutions to solve regional and national problems in energy and the environment. The Center cooperates with the School of Engineering at the University of Pittsburgh. All Fraunhofer projects are affiliated with local, state, and federal agencies, and private sectors. On-farm biogas generation using manure or other biomass is one of the technologies developed and successfully demonstrated by Fraunhofer. The technology's use has been extended to various applications, including sewage sludge treatment, industrial wastewater with high organic contents, co-digestion, and biowaste digestion.

### Gas Technology Institute

J. Robert Paterek, Ph.D.		<b>Tel:</b> 847/768-0720		
1700 Mount Prospect Road		<b>Ext:</b>	<b>Email:</b> <a href="mailto:robert.paterek@gastechnology.org">robert.paterek@gastechnology.org</a>	<b># Yrs in Business:</b> 53
Des Plaines	IL 60018	<b>Fax:</b> 847/768-0546	<b>Web:</b> <a href="http://www.gastechnology.org">www.gastechnology.org</a>	<b># Employees:</b> 320
US				

Gas Technology Institute (GTI) and the Environmental Science & Technology Center have been carrying out research and development projects and technology demonstrations in the areas of anaerobic digestion and biogas generation since the 1970s. GTI holds a number of patents on the

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## Industry Directory for On-Farm Biogas Recovery Systems

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two-phase reactor system and other reactor designs and systems. The two-phase digestion technology has been in full-scale commercial use for activated sludge treatment for more than five years. The two-stage system has proven successful for swine and dairy manure in large-scale laboratory evaluations and GTI is preparing for farm demonstrations and full-scale deployments.

### General Bioenergy, Inc.

Phillip Badger		<b>Tel:</b> 256/740-5634		
P.O. Box 26		<b>Ext:</b>	<b>Email:</b> <a href="mailto:pbadger@bioenergyupdate.com">pbadger@bioenergyupdate.com</a>	<b># Yrs in Business:</b> 3
Florence	AL	<b>Fax:</b> 256/740-5635	<b>Web:</b> <a href="http://www.bioenergyupdate.com">www.bioenergyupdate.com</a>	<b># Employees:</b> 4
US	35630			

Mr. Badger is the Technical Director for the Southeastern Regional Biomass Energy Program, which has funded a variety of projects related to farm-scale systems (mainly lagoon digester projects) and wastewater treatment plants. He publishes and sells the "Biogas Utilization Handbook." General Bioenergy has performed feasibility studies for farm biogas systems.

### MacMillan & Associates

Roy MacMillan		<b>Tel:</b> 503/628-0277		
17815 NE Courtney Road		<b>Ext:</b>	<b>Email:</b> <a href="mailto:rm@macmillan-group.com">rm@macmillan-group.com</a>	<b># Yrs in Business:</b> 30
Newberg	OR	<b>Fax:</b>	<b>Web:</b>	<b># Employees:</b> 6
US	97132			

MacMillan & Associates is an integrated engineering and consulting company that specializes in providing energy-related services to the agricultural community.

### MCON BIO, Inc.

Hans Meyer		<b>Tel:</b> 909/600-1385		
39642 Via Temprano		<b>Ext:</b>	<b>Email:</b> <a href="mailto:mconbio@mconbio.com">mconbio@mconbio.com</a>	<b># Yrs in Business:</b> 10
Murrieta	CA	<b>Fax:</b> 909/600-1285	<b>Web:</b> <a href="http://www.mconbio.com">www.mconbio.com</a>	<b># Employees:</b> 170
US	92563			

MCON BIO is a consulting, engineering, and management company that works with all aspects of biogas operations, from logistics and management to finished products applications. MCON BIO also represents Farmatic Biotech Energy AG, which builds complete biogas and waste water treatment plants.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### Meridian Capital Investments, Inc.

Gino Heilizer  
10220 River Road  
Potomac MD 20854  
US

**Tel:** 301/983-5000  
**Ext:**  
**Fax:** 301/983-9012

**Email:** [gheilizer@meridianinvestments.com](mailto:gheilizer@meridianinvestments.com)  
**Web:** [www.meridianinvestments.com](http://www.meridianinvestments.com)

**# Yrs in Business:** 15  
**# Employees:** 40

Meridian Investments is the largest provider of tax credit equity in America. Since 1992, the company has underwritten over \$8 billion worth of federal tax credits. Meridian Investments has experience in all major federal tax credit programs, including sections 42, 29, and 45. The company provides information on selling credits to clients with plants that currently generate or will be generating a qualifying fuel under section 29 or 45 of the IRC.

### National Methane

William J. Lingo, Sr.  
905 Glendean Avenue, Suite 7  
Riverside OH 45431  
US

**Tel:** 937/256-7500  
**Ext:**  
**Fax:** 937/256-7500

**Email:** [blingo@dma.org](mailto:blingo@dma.org)  
**Web:**

**# Yrs in Business:** 20  
**# Employees:** 5

National Methane holds a patent for a system that can verify the basis for each of the "multiple" avenues of income streams their system develops. National Methane provides complete farm evaluations and recommendations for incorporating biogas technology into a farm plan. National Methane has provided evaluations for more than 100 chicken farms, more than 60 swine farms, more than 25 dairy farms, and one sheep farm. The company also provides grant writing and public relations services related to on-farm biogas recovery and fee-based speakers for Community Groups and Agricultural Seminars.

### Nelson and Associates

D.O. "Swede" Nelson  
76 Almendral Avenue  
Atherton CA 94027

**Tel:** 650/364-7273  
**Ext:**  
**Fax:** 650/367-0365

**Email:** [swedenelson@msn.com](mailto:swedenelson@msn.com)  
**Web:**

**# Yrs in Business:** 18  
**# Employees:** 12

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US

Nelson and Associates is a domestic and international consulting group specializing in the planning, technical study, implementation, and financing of petroleum and environmental projects. The company is affiliated with firms with extensive experience in biogas projects and is currently completing design, installation, and start-up of a bioremediation and thermal desorption project in the western United States.

### Omega-Alpha Recycling Systems

Robert Hamburg		<b>Tel:</b> 304/655-8662			
Route 1, Box 51		<b>Ext:</b>	<b>Email:</b> anomalous@citlink.net	<b># Yrs in Business:</b>	24
Orma	WV 25268	<b>Fax:</b> NA	<b>Web:</b>	<b># Employees:</b>	1
US					

Omega-Alpha Recycling Systems (OARS) works on projects related to organic recycling and biogas systems integrated with organic farming and permaculture facilities. OARS has designed four small-scale, ambient temperature digesters: 1) Arcadia Farm, a goat, chicken, and horse farm in Orma, West Virginia with a Chinese style extended batch digester; 2) Urbanic Farm, a horse, cow, and chicken farm in Chloe, West Virginia with a Chinese style extended batch digester; 3) Agriculture Research Farm, a swine farm in Bamaco, Mali, West Africa with a Chinese style extended batch digester; and 4) the Mandali School, a school with cattle, in Chhopark, Nepal, an Indian design Gobar Gas demonstration project. OARS was also instrumental in halting a project that was environmentally and economically unsound.

### R. K. Frobel & Associates

Ronald K. Frobel, P.E.		<b>Tel:</b> 303/679-0285			
1153 Bergen Parkway; Suite M-240		<b>Ext:</b>	<b>Email:</b> geosynthetics@msn.com	<b># Yrs in Business:</b>	15
Evergreen	CO 80439	<b>Fax:</b> 303/679-8955	<b>Web:</b>	<b># Employees:</b>	3
US					

Established in 1988, R.K. Frobel & Associates Consulting Engineers provides design and construction assistance in the growing field of geosynthetics, including design assistance in both animal waste lining systems and cover systems for waste/anaerobic digesters. Design assistance is provided to full-service engineering firms or facility/farm owners. As principal of R.K.Frobel & Associates, Mr. Frobel has over 25 years of experience in synthetic lining and cover systems, including agricultural applications.

### Richmond Energy Associates

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## Industry Directory for On-Farm Biogas Recovery Systems

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Jeff Forward		<b>Tel:</b> 802/434-3770			
P.O. Box 615		<b>Ext:</b>	<b>Email:</b> forward@sover.net	<b># Yrs in Business:</b>	3
Richmond	VA 05477	<b>Fax:</b> 802/434-2344	<b>Web:</b>	<b># Employees:</b>	1
US					

Richmond Energy Associates is a renewable energy company specializing in anaerobic digestion feasibility analysis.

### Robert A. Beckstrom, Electrical Consultant

Robert (Bob) Beckstrom		<b>Tel:</b> 209/576-1740			
1512 Gladwin Lane		<b>Ext:</b>	<b>Email:</b>	<b># Yrs in Business:</b>	NA
Modesto	CA 95355	<b>Fax:</b>	<b>Web:</b>	<b># Employees:</b>	1
US					

Mr. Beckstrom provides electrical design and consulting services and specializes in alternative power projects. He wrote the electrical specifications for the first 100 wind generators installed on the Altamont Pass. In addition, Mr. Beckstrom participated in the design of the first geothermal test well in Hawaii, as well as several hydro-electric plants.

### Selective Site Energy

Terry Super		<b>Tel:</b> 913/438-7700			
8500 West 110th Street, Suite 300		<b>Ext:</b>	<b>Email:</b> terry.super@selectivesite.com	<b># Yrs in Business:</b>	1
Overland Park	KS 66210	<b>Fax:</b> 913/438-7777	<b>Web:</b> <a href="http://www.selectivesite.com">www.selectivesite.com</a>	<b># Employees:</b>	4
US					

Selective Site Energy was formed as a division of Selective Site Consultants, a wireless telecommunications, cellular tower, and facility design-build consultancy. All the principles, partners, engineers, and related professional staff at SSC/SSE have extensive backgrounds in all forms of engineering and construction projects, including water and wastewater treatment, power, and cogeneration.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### The Dubara Company

Stephen Hoyt  
1177 Route 9  
Castleton NY 12033  
US

**Tel:** 518/732-7618

**Ext:**

**Fax:** 518/732-7618

**Email:** [steveh@albany.net](mailto:steveh@albany.net)

**Web:**

**# Yrs in Business:** 2

**# Employees:** 1

The Dubara Company is currently operating three pilot reactors for the Vermont Department of Public Service and testing the rate of digestion of whole dairy manure. The company hopes to increase the rate of digestion and reduce the size of digesters, and to address ways to remove sediment and prevent its accumulation.

### Consultants

### Tim Goodman & Associates

Tim Goodman  
2337 Texas Avenue South  
St. Louis Park MN 55426  
US

**Tel:** 952/544-6005

**Ext:**

**Fax:** 952/544-2307

**Email:** [tgoodman1@mn.rr.com](mailto:tgoodman1@mn.rr.com)

**Web:**

**# Yrs in Business:** 1

**# Employees:** 1

Tim Goodman & Associates has experience in a variety of biomass projects, including green waste composting, food waste composting, and biomass-to-energy facilities. The company can provide feasibility studies for anaerobic digestion of animal waste at farms and feedlot operations, biogas system design, and vendor procurement assistance.

### Universal Entech, LLC

Daniel Musgrove  
5501 N. 7th Avenue, PMB 233  
Phoenix AZ 85013-1756  
US

**Tel:** 602/268-8849

**Ext:**

**Fax:** 602/268-9742

**Email:** [dmusgrove@earthlink.net](mailto:dmusgrove@earthlink.net)

**Web:**

**# Yrs in Business:** 10

**# Employees:** 12

Universal Entech, LLC is an organic resource management company providing manure management and wastewater treatment services to the CAFO industry. The company focuses on developing turnkey solutions that comply with its clients' nutrient management plans and discharge

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# Industry Directory for On-Farm Biogas Recovery Systems

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requirements. Universal Entech's team has extensive experience in the development and operation of renewable energy systems utilizing biogas from municipal wastewater and landfill applications.

### Williams Creek Consulting, Inc.

Joel Johnston	<b>Tel:</b> 317/722-9567		
P.O. Box 20821	<b>Ext:</b>	<b>Email:</b> <a href="mailto:jjohnston@williamscreek.net">jjohnston@williamscreek.net</a>	<b># Yrs in Business:</b> 1
Indianapolis IN 46220	<b>Fax:</b> 317/726-0703	<b>Web:</b>	<b># Employees:</b> 4
US			

Williams Creek Consulting, Inc. specializes in designing and building natural wastewater treatment systems, including hybrid wetland systems. The company is currently working to incorporate biogas recovery into these systems to maximize potential energy usage.

### Developers

#### ADI Systems Inc.

Albert A. Cocci	<b>Tel:</b> 603/893-2134		
182 Main Street, Unit 6	<b>Ext:</b>	<b>Email:</b> <a href="mailto:acocci@adi.ca">acocci@adi.ca</a>	<b># Yrs in Business:</b> 13
Salem NH 03079	<b>Fax:</b> 603/898-3991	<b>Web:</b> <a href="http://www.adi.ca">www.adi.ca</a>	<b># Employees:</b> 15
US			<b>Farm Projects:</b> 0

ADI Systems has been involved in approximately 100 full-scale anaerobic system installations throughout the world. Approximately 50 of these systems treat agri-waste from food-related processing, while the remaining systems treat brewery, beverage, and chemical wastes. Each of these systems involves biogas collection and flaring or utilization (in most cases via burning in a boiler to produce hot water and steam). In several instances, utilization has involved cogeneration.

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### Ag Environmental Solutions

Carl Theunis  
2768 Poplar Street  
Kaukauna WI 54130  
US

**Tel:** 920/532-4804

**Ext:**

**Email:** aes@athenet.net

**Fax:** 920/532-5039 **Web:** ag-env-sol.com

**# Yrs in Business:** 3

**# Employees:** 6

**Farm Projects:** 1

Ag Environmental Solutions employs a process patented by and licensed to Iowa State Research. Ag Environmental Solutions' Tinedale Project is one of the largest dairy farm biogas systems in the United States with a 2,500-head capacity. The process is a complete mix using thermophilic and mesophilic temperatures enabling the system to produce a Class A bio-solid.

### Agri Bio Systems

Richard Vetter, PhD, PAS, ACAN  
2333 Tara Drive  
Elgin IL 60123  
US

**Tel:** 847/888-7854

**Ext:**

**Email:** rvagribio@aol.com

**Fax:** 847/888-1484 **Web:**

**# Yrs in Business:** 18

**# Employees:** NA

**Farm Projects:** 7

Agri Bio Systems performs feasibility assessments and designs and installs biogas systems in the United States and abroad. Examples of biogas systems include: 1) Lindstrom Farm: a 50-cow dairy farm in Welch, Minnesota; 2) Leefer Farm, a 1,000-cow beef confinement farm in Carbin Carlinville, Illinois; 3) Smith Farm, a 70,000-broiler poultry farm in Princeton, North Carolina; 4) Naser Farm, a 1,000-sow finishing swine farm in Sibley, Iowa; 5) Hamilton Farm, a 450-sow finishing farm and a 120,000-layer poultry farm in Iowa Falls, Iowa; 6) Huntington Dairy, a 300-cow dairy farm in Cooperstown, New York; 7) Cushman Farm, a 600-cow dairy in Franklin, Connecticut; and 8) International Project, Taiwan, Environmental Training Center for Waste Management.

### AnAerobics

Sarah Ploss  
P.O. Box 307, Aurora Place, Suite 202  
Aurora NY 13026  
US

**Tel:** 315/364-5062

**Ext:**

**Email:** info@anaerobics.com

**Fax:** 315/364-7713 **Web:** [www.anaerobics.com](http://www.anaerobics.com)

**# Yrs in Business:** 7

**# Employees:** 13

**Farm Projects:** 1

AnAerobics delivers treatment of organic waste streams using proprietary and patented technologies that create opportunities for renewable energy utilization. Methane gas produced by the company's patented process is used at its treatment sites to operate boilers that heat wastewater for

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treatment. The methane can also be cleaned and used as a natural gas alternative.

### Anergen Corporation

Esh Noojibail	<b>Tel:</b> 847/498-4545		
663 Academy Drive	<b>Ext:</b>	<b>Email:</b> enoojibail@anergen.com	<b># Yrs in Business:</b> 17
Northbrook IL 60062-2420	<b>Fax:</b> 847/498-4547	<b>Web:</b> <a href="http://www.anergen.com">www.anergen.com</a>	<b># Employees:</b> 25
US			<b>Farm Projects:</b> 0

Anergen specializes in designing and installing waste mitigation systems for agricultural and industrial organic wastes to recover biogas, reduce BOD, eliminate odor, separate nutrients, and generate electricity from biogas. Anergen has a fully instrumented, state-of-the-art pilot plant that can be used to test the material before installing the system. Anergen does not design and install any systems without performing a trial on the waste material at the pilot plant. Anergen uses the latest anaerobic technology, which generates 50 to 75 percent more biogas than conventional technologies. Average payback is three to six years with positive cash flow. The performance is guaranteed.

### Applied Technologies, Inc.

John F. Kouba	<b>Tel:</b> 262/784-7690		
16815 W. Wisconsin Avenue	<b>Ext:</b>	<b>Email:</b> jfkouba@ati-ae.com	<b># Yrs in Business:</b> 15
Brookfield WI 53005	<b>Fax:</b> 262/784-6847	<b>Web:</b>	<b># Employees:</b> 54
US			<b>Farm Projects:</b> 2

Applied Technologies, Inc. (ATI) is an engineering design and consulting firm that has designed its own anaerobic contact process. ATI has cosponsored seminars on anaerobic treatment of agricultural and high-strength wastes for the past 10 years. The company designed a complete mix anaerobic digester for poultry manure for Maple Leaf Farms in Wisconsin and a complete mix anaerobic digester for poultry manure and slaughter wastewater for Crescent Duck in New York.

### BioWaste Energy, Inc.

Zia Khan	<b>Tel:</b> 209/465-0296		
P.O. Box 8520	<b>Ext:</b>	<b>Email:</b> ziakhan@pacbell.net	<b># Yrs in Business:</b> 30
Stockton CA 95208	<b>Fax:</b> 209/465-1605	<b>Web:</b> <a href="http://home.pacbell.net/ziakhan">http://home.pacbell.net/ziakhan</a>	<b># Employees:</b> 20
US			<b>Farm Projects:</b> 0

BioWaste Energy, Inc. and its predecessors have provided quality services to industries and municipalities since 1972 and have completed more than 300 power generation projects in the United States and abroad. The company develops and finances zero discharge projects utilizing

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anaerobic technology. These projects treat solid and liquid waste and produce saleable products, including electricity generated from methane, liquid fertilizer, CO<sub>2</sub>, soil amendments, and recycled potable water. These facilities provide zero solid and liquid discharge. The company offers a full range of services covering all phases of project development from planning, feasibility studies, engineering design, equipment and systems supply, and construction and installation to start-up and operations.

### EA Engineering, Science, and Technology

Robert Newman	<b>Tel:</b> 410/592-7269			
15 Loveton Circle	<b>Ext:</b>	<b>Email:</b> rnewman@eaest.com	<b># Yrs in Business:</b>	28
Sparks MD 21152	<b>Fax:</b> 410/771-4204	<b>Web:</b> <a href="http://www.eaest.com">www.eaest.com</a>	<b># Employees:</b>	400
US			<b>Farm Projects:</b>	0

EA Engineering, Science, and Technology focuses on biogas projects (i.e., conceptualization, design, building), primarily at meat-processing facilities. For example, the firm is currently constructing a lagoon enclosure in Texas with the capacity to collect 60,000 cubic feet of biogas, which will be ducted to boilers on-site. Virtually all methane will be oxidized.

### Environmental Energy Company

Dennis Burke	<b>Tel:</b> 360/923-2000			
6007 Hill Road NE	<b>Ext:</b>	<b>Email:</b> dab@cyclus.com	<b># Yrs in Business:</b>	12
Olympia WA 98516	<b>Fax:</b> 360/923-1642	<b>Web:</b> <a href="http://www.makingenergy.com">www.makingenergy.com</a>	<b># Employees:</b>	12
US			<b>Farm Projects:</b>	0

Environmental Energy Company, formerly Cyclus Envirosystems (a division of Western Environmental Engineering), solves waste management problems through innovative process technologies. The company developed and patented new anaerobic and flotation processes that allow them to solve waste management problems at significantly less cost and with better capture of components.

### Environmental Products & Technology Company (EPTC)

Marvin Mears	<b>Tel:</b> 818/865-2205			
3380 N. Sterling Ctr. Drive	<b>Ext:</b>	<b>Email:</b> marvin@eptcorp.com	<b># Yrs in Business:</b>	7
Westlake Village CA 91361-4612	<b>Fax:</b> 818/865-2205	<b>Web:</b> <a href="http://eptcorp.com">eptcorp.com</a>	<b># Employees:</b>	9
US			<b>Farm Projects:</b>	0

Environmental Products & Technology Company (EPTC) developed two anaerobic digester projects at Utah State University. Both systems are

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multi-tank systems with the objective of developing short HRT cycles. Short HRT can reduce both the size of the system and system-related costs. EPTC has developed a closed loop waste management system designed to treat and convert an organic waste product into a series of desirable and marketable reuse products.

### Environomics

Richard Mattocks	<b>Tel:</b> 718/884-6740		
5700 Arlington Avenue, Suite 17A	<b>Ext:</b>	<b>Email:</b> utter@compuserve.com	<b># Yrs in Business:</b> 20
Riverdale            NY    10471	<b>Fax:</b> 718/884-6726	<b>Web:</b> <a href="http://www.waste2profits.com">www.waste2profits.com</a>	<b># Employees:</b> 2
US			<b>Farm Projects:</b> 24

Environomics has worked on over 20 farm-scale biogas digester projects. These projects include plug-flow digesters for multiple dairy facilities throughout the United States, ranging in size from 30 to 1,000 cows. Depending on the farm, the biogas is used to generate electricity, fuel boiler systems, or both. The remaining farm-scale projects include mixed digesters for several swine farms throughout the United States for farrow-to-finish farms, ranging in size from 1,000 to 3,000 sows. The swine farms use the biogas to generate electricity. In addition, Environomics is experienced in permitting, utility negotiations, public relations, feasibility studies, and publications.

### Feldmann and Associates

Terry Feldman, P.E.	<b>Tel:</b> 309/822-9828		
410 Illinois Street, Suite C	<b>Ext:</b>	<b>Email:</b> tlfeldmann@aol.com	<b># Yrs in Business:</b> 10
Spring Bay            IL    61611	<b>Fax:</b> 309/822-9829	<b>Web:</b>	<b># Employees:</b> 5
US			<b>Farm Projects:</b> 2

Feldmann and Associates collaborated with AgSTAR to design a complete mix digester for Apex Pork in Rio, Illinois, an AgSTAR demonstration farm. The company has other biogas projects in the planning and construction phases, including Inwood Dairy in Elmwood, Illinois, a plug flow dairy project, and New Image, LLC, a complete mix swine digester. Feldmann is focused on advising farmers to increase production efficiency and improve manure-handling methods.

### Fox Engineering Associates, Inc.

Dale Watson	<b>Tel:</b> 515/233-0000		
1601 Golden Aspen Drive	<b>Ext:</b>	<b>Email:</b> dwatson@foxeng.com	<b># Yrs in Business:</b> 40
Ames                    IA    50010	<b>Fax:</b> 515/233-0103	<b>Web:</b> <a href="http://www.foxeng.com">www.foxeng.com</a>	<b># Employees:</b> 38

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US **Farm Projects:** 2

Fox Engineering specializes in environmental and civil engineering services for industrial, municipal, and agricultural sectors. The company focuses on water, wastewater, soil, and air media issues and has designed a digester for Crawford Farm (demonstration project), a swine farm in Nevada, Iowa.

### GHD Inc.

Steve Dvorak			<b>Tel:</b> 920/849-9797			
P.O. Box 69			<b>Ext:</b>	<b>Email:</b> ddghd@tds.net	<b># Yrs in Business:</b>	13
Chilton	WI	53014	<b>Fax:</b> 920/849-9160	<b>Web:</b>	<b># Employees:</b>	12
US					<b>Farm Projects:</b>	6

GHD provides engineering and system installation experience in the anaerobic digester industry. GHD has five operating anaerobic digesters utilizing its proprietary mixed plug flow digester design in the Midwest and one additional digester under construction.

### Hadley and Bennett, Inc.

Spencer Bennett			<b>Tel:</b> 603/428-3851			
P.O. Box 517			<b>Ext:</b>	<b>Email:</b> bennettfarm@conknet.com	<b># Yrs in Business:</b>	NA
Henniker	NH	03242	<b>Fax:</b> 603/428-3851	<b>Web:</b>	<b># Employees:</b>	1
US					<b>Farm Projects:</b>	6

Hadley and Bennett, Inc. designs and builds anaerobic digesters. Examples of projects include: 1) Hadley Farm, a dairy in Henniker, New Hampshire; 2) Foster Brothers, a dairy in Middlebury, Vermont; 3) Tait Farm, a veal farm in North Whitefield, Maine; 4) Shugah Vale, a dairy in Claremont, New Hampshire; 5) Curtin Brothers, a dairy in Oneida, New York; and 6) Bruce Farm, a dairy in Oldenburg, New York.

### Orgo Systems, Inc.

Mayyar Irani			<b>Tel:</b> 570/374-4402			
16 White Block			<b>Ext:</b>	<b>Email:</b> mayyar@orgosystems.com	<b># Yrs in Business:</b>	4
Selingsgrove	PA	17870	<b>Fax:</b> 570/374-0487	<b>Web:</b> <a href="http://orgosystems.com">orgosystems.com</a>	<b># Employees:</b>	3
US					<b>Farm Projects:</b>	1

Orgo System's farm project is a 1,100 farrow-to-finish hog operation with a 4,000-hog capacity. The 24-kW engine currently supplies electricity

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to the barn, and the project will soon upgrade to a 100-kW engine. Orgo Systems designed an operational prototype that produces electricity, reduces odors, and separates solids for better handling of waste. Orgo Systems is working on plans for a second generation digester system at a 300-cow dairy that will digest, separate, compost, and aerate for total nutrient management.

### PRIME Technologies, LLC

Phillip D. Lusk		<b>Tel:</b> 605/945-1311		
108 E. Missouri Avenue		<b>Ext:</b>	<b>Email:</b> <a href="mailto:plusk@primecapture.com">plusk@primecapture.com</a>	<b># Yrs in Business:</b> 3
Pierre	SD	<b>Fax:</b> 605/945-0194	<b>Web:</b> <a href="http://www.primecapture.com">www.primecapture.com</a>	<b># Employees:</b> 16
US	57501			<b>Farm Projects:</b> 0

The proposed PRIME Technologies biorefinery includes a locally managed system comprised of a 20-million gallon/year ethanol plant that uses local crops and an adjoining 28,000-head confined cattle feedlot connected to an anaerobic digester. Independent contractors will run “backgrounding” operations with additional 13,000- to 15,000-head of cattle. The complex will produce fuel-grade ethanol, finished cattle, biogas, and biofertilizers. The biorefinery is economically attractive, with an estimated internal rate of return of approximately 30 percent, achievable through significant economies of scope. A commercial demonstration of this referenced biorefinery is undergoing final detailed engineering and project development at a site located outside of Pierre, South Dakota. Construction is scheduled to commence late spring of 2002 and start-up is scheduled for the summer of 2003.

### RCM Digesters, Inc.

Mark Moser		<b>Tel:</b> 510/658-4466		
P.O. Box 4716		<b>Ext:</b>	<b>Email:</b> <a href="mailto:rcmdigesters@att.net">rcmdigesters@att.net</a>	<b># Yrs in Business:</b> 18
Berkeley	CA	<b>Fax:</b> 510/658-2729	<b>Web:</b> <a href="http://www.rcmdigesters.com">www.rcmdigesters.com</a>	<b># Employees:</b> 2
US	94704			<b>Farm Projects:</b> 30

RCM Digesters, Inc. has designed 30 farm-scale biogas projects. Examples include: 1) Apex Pork (for AgSTAR), a swine farm in Rio, Illinois with a covered, heated, mixed lagoon; 2) Freund Dairy (for AgSTAR), a dairy farm in East Canaan, Connecticut with a plug flow digester; 3) AA Dairy (for AgSTAR), a dairy farm in Candor, New York; 4) Martin Hog Farm (for AgSTAR), a swine farm in South Boston, Virginia with a covered lagoon; 5) Barham Hog Farm (for AgSTAR), a swine farm in Zebulon, North Carolina with a covered lagoon; 6) Craven Dairy, a dairy farm in Cloverdale, Oregon with a plug flow digester; 7) Cal Poly Dairy (for AgSTAR), a dairy farm in San Luis Obispo, California with a covered lagoon; 8) Palmer Hog Farm, a swine farm in Yell County, Arkansas with a covered lagoon; 9) Tohoku Farm, a swine farm in Aamori Prefecture, Japan with a mixed digester; and 10) Langerwerf Dairy, a dairy farm in Durham, California with a plug flow digester.

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### Sharp Energy, Inc.

Roy Sharp		<b>Tel:</b> 559/688-2051		
24684 Road 148		<b>Ext:</b>	<b>Email:</b> rsharp6363@aol.com	<b># Yrs in Business:</b> 18
Tulare	CA 93274	<b>Fax:</b> 559/688-1111	<b>Web:</b>	<b># Employees:</b> 2
US				<b>Farm Projects:</b> 5

Sharp Energy, Inc. consults, designs, and sets up effective and efficient waste management and energy production systems. Sharp Energy developed systems for the following farms: 1) Royal Farms, a 16,000-head swine farm in Tulare, California; 2) Sharp Ranch, a 5,000-head swine farm in Tulare, California; 3) Sharp Enterprises, an 8,000-head swine farm in Caruthers, California; and 4) Petrorio Farm, a 3,000-head swine farm in Skopje, Macedonia. Sharp Energy designed covers for the following farms: Cal Poly San Luis Obispo (an AgSTAR Demonstration Farm), a 300-cow dairy in San Luis Obispo, California; and Laurenco Dairy, a 1,200-cow dairy in Tulare, California.

### Synagro

Paul Sellew		<b>Tel:</b> 978/371-0501		
1800 Bering Drive, Suite 1000		<b>Ext:</b>	<b>Email:</b> psellew@synagro.com	<b># Yrs in Business:</b> 16
Houston	TX 77057	<b>Fax:</b> 713/369-1750	<b>Web:</b> <a href="http://www.synagro.com">www.synagro.com</a>	<b># Employees:</b> 1,000
US				<b>Farm Projects:</b> 1

Synagro operates at over 1,000 wastewater treatment plants throughout the country, providing operations and residuals management services. Many of these wastewater treatment plants employ anaerobic digestion. The company is using this experience to expand into the agribusiness market with its first operational facility, which was designed and built in Chino, California. This digester is designed for 225 wet tons of fresh cow manure per day. It employs dewatering and onsite cogeneration using Capstone Microturbines.

### Williams Engineering Associates

Doug Williams, P.E.		<b>Tel:</b> 805/528-0131		
2073 Buckskin Drive		<b>Ext:</b>	<b>Email:</b> wmsengre@thegrid.com	<b># Yrs in Business:</b> 17
Los Osos	CA 93402	<b>Fax:</b>	<b>Web:</b>	<b># Employees:</b> 1
US				<b>Farm Projects:</b> 1

Williams Engineering Associates specializes in anaerobic digestion, biogas energy utilization, energy conservation, and farm machinery systems. The company has designed and developed many methane digester systems for dairy and swine facilities.

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### Equipment Suppliers/Distributors: Covers

#### **Dennis Gerber, Consultant**

Dennis Gerber  
15870 Rose Avenue  
Los Gatos CA 95030  
US

**Tel:** 408/395-9020

**Ext:**

**Email:** dhgerber@attbi.com

**# Yrs in Business:** NA

**Fax:** 408/395-9020

**Web:**

**# Employees:** NA

Mr. Gerber designs and installs anaerobic digester covers. His Gas Collecting Floating Cover design, which holds a U.S. Patent, is the de-facto standard for flexible membrane anaerobic digesters.

#### **Engineered Textile Products**

Carter Damp  
P.O. Box 7474  
Mobile AL 36670  
US

**Tel:** 800/222-8001

**Ext:**

**Email:** cdamp2@aol.com

**# Yrs in Business:** 20

**Fax:** 888/222-8277

**Web:** [www.etpinfo.com](http://www.etpinfo.com)

**# Employees:** 36

Engineered Textile Products, Inc. manufactures and distributes lagoon covers. The company manufactured the covers for Martin's Farm, a swine farm with a covered lagoon in South Boston, Virginia, and Palmers Farm, a swine farm with a covered lagoon in Petite Jean Mt., Arkansas.

#### **Environmental Fabrics, Inc.**

Ray E. Pickel  
85 Pascon Court  
Gaston SC 29053  
US

**Tel:** 803/551-5700

**Ext:**

**Email:**

**# Yrs in Business:** 6

**Fax:** 803/551-5701

**Web:**

**# Employees:** 30

Environmental Fabrics Inc. has manufactured covers for five farms, including: 1) Dowell Ramsey Farm, a swine farm in Nash County, North Carolina; 2) Gold 'N Plump Poultry, a poultry farm in Cold Springs, Minnesota; 3) Pelican Rapids, a farm in Pelican Rapids, Minnesota; 4) Apex Pork, a swine farm in Rio, Illinois; and 5) Barham Farms, a swine farm in Zebulon, North Carolina.

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### Firestone Building Products Company

William Johnson      **Tel:** 800/428-4442  
575 Congressional Blvd.      **Ext:**      **Email:** johnsonwilliam@firestonebp.com      **# Yrs in Business:** 18  
Carmel      IN      46032      **Fax:** 317/575-7002      **Web:** [www.firestonebpco.com](http://www.firestonebpco.com)      **# Employees:** 1300  
US

Firestone Building Products Company manufactures a variety of EPDM rubber geosynthetic products for agricultural use. Firestone can recommend a network of independent installers familiar with agricultural installations and Firestone's products. Firestone Building Products Company can advise customers in the selection of a cost-effective selection of EPDM rubber geosynthetic products for a number of agricultural uses, including biogas recovery.

### GSE Lining Technology, Inc.

Don Diguilio      **Tel:** 800/446-8216  
167 Anderson Road      **Ext:** 608      **Email:** ddiguilio@gseworld.com      **# Yrs in Business:** 20  
Cranberry Township      PA      16066      **Fax:** 724/452-3195      **Web:** [www.gseworld.com](http://www.gseworld.com)      **# Employees:** 1,200  
US

GSE Lining Technology, Inc. provides geosynthetic products and installation services to the agriculture industry. GSE's experienced staff assists customers in selecting the right materials to line livestock ponds to prevent contamination.

### Industrial & Environmental Concepts, Inc.

Mike Morgan      **Tel:** 952/829-0731  
6009 Chapel Drive      **Ext:**      **Email:** mmorgan@ieccovers.com      **# Yrs in Business:** 10  
Minneapolis      MN      55439      **Fax:** 952/829-9770      **Web:** [www.ieccovers.com](http://www.ieccovers.com)      **# Employees:** 5 to 25  
US

Industrial & Environmental Concepts, Inc. (IEC) produces and installs five types of floating modular covers for ponds and tanks. IEC's patented systems utilize a variety of geomembranes to provide cost-effective solutions to control problems with heat loss, odor, algae growth, and gas production in basins, ponds, lagoons, or tanks.

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### MPC Containment

Edward Reicin		<b>Tel:</b> 773/927-4120		
4834 South Oakley		<b>Ext:</b>	<b>Email:</b> ereic@aol.com	<b># Yrs in Business:</b> 80
Chicago	IL	<b>Fax:</b> 773/650-6028	<b>Web:</b> <a href="http://www.mpccontainment.com">www.mpccontainment.com</a>	<b># Employees:</b> 50
US	60609			

MPC Containment designs, fabricates, and installs floating-membrane liner systems, as well as other primary and secondary containment systems. The company also manufactures collapsible storage/pillow tanks for fuel, water, and waste.

### Equipment Suppliers/Distributors: Engines

#### California Power Partners, Inc.

Tom Moore		<b>Tel:</b> 858/277-8585		
3944 Murphy Canyon Road; Suite		<b>Ext:</b>	<b>Email:</b> tomm@calpwr.com	<b># Yrs in Business:</b> 3
San Diego	CA	<b>Fax:</b> 858/277-8514	<b>Web:</b> <a href="http://www.calpwr.com">www.calpwr.com</a>	<b># Employees:</b> 18
US	92123			

California Power Partners, Inc. is a turn-key provider of services to the distributed generation and cogeneration industry. Its services include financial and technical analysis, engineering, equipment supply, project management, construction, financing, O&M, and other related activities.

#### Capstone Turbine Corporation

George Wiltsee		<b>Tel:</b> 818/734-5300		
21211 Nordhoff Street		<b>Ext:</b>	<b>Email:</b> gwiltsee@capstoneturbine.com	<b># Yrs in Business:</b> 14
Chatsworth	CA	<b>Fax:</b> 818/734-5320	<b>Web:</b> <a href="http://www.microturbine.com">www.microturbine.com</a>	<b># Employees:</b> 275
US	91311			

Capstone manufactures microturbines that can burn biogas with as little as 35 percent methane content. The currently available biogas model is a 30-kW microturbine that was initially offered for natural gas, propane, oil field waste gas, and diesel. During early 2000, a demonstration test program was conducted with Los Angeles County Sanitation Districts at Puente Hills landfill and at Palmdale wastewater treatment plant. Successful testing during 2000 led to commercial operations at 20 biogas facilities, as of March, 2002, using a total of 117 Capstone microturbines. The Capstone microturbine achieves a combustion efficiency of 99.999 percent. The patented premix combustion system is uniquely designed to reduce emissions of NO<sub>x</sub>, CO, and hydrocarbons to extremely low levels.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### Caterpillar, Inc.

Rob Schueffner	<b>Tel:</b> 309/578-6376		
PO Box 610; AC6109	<b>Ext:</b>	<b>Email:</b> <a href="mailto:schuerd@Cat.com">schuerd@Cat.com</a>	<b># Yrs in Business:</b> 75
Mossville IL 61525	<b>Fax:</b> 309/578-7302	<b>Web:</b> <a href="http://www.cat.com">www.cat.com</a>	<b># Employees:</b> 80
US			

For more than 75 years, Caterpillar, Inc. has been building the world's infrastructure. In partnership with Caterpillar dealers, it is driving sustainable change in every continent. A Fortune 100 company, Caterpillar is the world's leading manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines. The company is a technological leader in construction, transportation, mining, forestry, energy, logistics, electronics, financing, and electric power generation.

### Charles Equipment Company

	<b>Tel:</b> 800/842-4279		
PO Box 388	<b>Ext:</b>	<b>Email:</b> <a href="mailto:cec@charlesequipment.com">cec@charlesequipment.com</a>	<b># Yrs in Business:</b> 40
Addison IL 60101	<b>Fax:</b> 630/543-4174	<b>Web:</b> <a href="http://www.charlesequipment.com">www.charlesequipment.com</a>	<b># Employees:</b> 35
US			

Charles Equipment Company has specialized in reciprocating engine power systems for businesses, homes, and municipalities for more than 43 years. Charles Equipment Company has three offices located across the Midwest, providing full service in Illinois, Indiana, Michigan, Wisconsin, and Northwest Ohio.

### Coffman Electrical Equipment

Greg Mulder	<b>Tel:</b> 616/452-8708		
3300 Jefferson SE	<b>Ext:</b>	<b>Email:</b> <a href="mailto:gmulder@steadypower.com">gmulder@steadypower.com</a>	<b># Yrs in Business:</b> 54
Grand Rapids MI 49548	<b>Fax:</b> 616/452-1337	<b>Web:</b> <a href="http://www.steadypower.com">www.steadypower.com</a>	<b># Employees:</b> 16
US			

As distributors of Hess Microgen and Bowman Power Microturbine cogeneration systems, Coffman Electrical Equipment offer digester consultation, proven electrical production, and hot water absorption chilling. The company works with both single and multiple stage digesters.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### DTE Energy Technologies, Inc. (Power Partner of Waukesha Engines)

John Macgowan		<b>Tel:</b> 800/472-3585			
1715 Lake Drive West		<b>Ext:</b>	<b>Email:</b> <a href="mailto:macgowanj@dteenergy.com">macgowanj@dteenergy.com</a>	<b># Yrs in Business:</b>	90
Chanhassen	MN	<b>Fax:</b> 952/448-9302	<b>Web:</b> <a href="http://www.dtech.com">www.dtech.com</a>	<b># Employees:</b>	1000+
US	55317				

Waukesha Engine is a leading manufacturer of stationary natural gas, methane, and biogas powered engines. DTE Energy provides comprehensive application engineering services to help ensure systems are configured to each customer's specific requirements and energy objectives.

### FlexEnergy, Inc.

Edan Prabhu		<b>Tel:</b> 949/380-4899			
22922 Tiagua		<b>Ext:</b>	<b>Email:</b> <a href="mailto:edanprabhu@cox.net">edanprabhu@cox.net</a>	<b># Yrs in Business:</b>	6
Mission Viejo	CA	<b>Fax:</b> 949/380-8407	<b>Web:</b>	<b># Employees:</b>	2
US	92692				

FlexEnergy is developing the Flex-Microturbine® to expand the range of biomass-derived gases that can be converted to electricity. Proof-of-concept testing was successful, and several prototype units are currently being built for testing on dairy digester gas, landfill gas, and producer gas from wood and nutshell gasification. Flex-Microturbine accepts gases at atmospheric pressure. This technology will be commercially available in two years.

### Ingersoll-Rand

Holly Emerson		<b>Tel:</b> 704/896-4051			
800A Beaty Street		<b>Ext:</b>	<b>Email:</b> <a href="mailto:holly_emerson@irco.com">holly_emerson@irco.com</a>	<b># Yrs in Business:</b>	130
Davidson	NC	<b>Fax:</b> 704/896-4327	<b>Web:</b> <a href="http://www.irenergysystems.com">www.irenergysystems.com</a>	<b># Employees:</b>	NA
US	28036				

Ingersoll-Rand (IR)'s EcoWorks microturbine systems turn digester gas into electricity and hot water. IR offers compact, integrated cogeneration packages that reduce NOx emissions and odors associated with flaring. IR's solution includes a fuel conditioner to compress and clean the biogas for reliable long-term operation at low O&M costs.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### Martin Machinery LLC

Harlan Martin		<b>Tel:</b> 660/458-7000		
39425 Excelsior Drive		<b>Ext:</b>	<b>Email:</b> sales@martinmachinery.com	<b># Yrs in Business:</b> 26
Latham	MO	65050	<b>Fax:</b> 660/458-7100	<b>Web:</b>
US				<b># Employees:</b> 20

Martin Machinery first entered the biogas industry in 1982 with the design and construction of 850-kW switch gear to parallel an induction generator to the utility. Additionally, the company supplied one 50-kW, one 100-kW, and four 350-kW electric biogas generator systems. Since the 1980s, the company has continued work on its Custom Designed Paralleling Switch Gear, making several updates as new technology became available. The company currently custom designs new and rebuilt electric generator systems to operate using biogas. It also services biogas units powered by engines with 460-cubic-inch to 7,040-cubic-inch engine blocks.

### MCX Environmental Energy Corp.

Rasheed Mustakeem		<b>Tel:</b> 404/816-2892		
110 East Andrews Drive - Suite 309		<b>Ext:</b>	<b>Email:</b> rasheed@mcxeec.com	<b># Yrs in Business:</b> 10
Atlanta	GA	30305	<b>Fax:</b> 404/237-7160	<b>Web:</b> <a href="http://www.mcxeec.com">www.mcxeec.com</a>
US				<b># Employees:</b> 7

Global distributor of the Capstone microturbine.

### Stewart & Stevenson, Distributed Energy Solutions

Jim Jodice		<b>Tel:</b> 253/931-0138		
10750 Telge Road		<b>Ext:</b>	<b>Email:</b> j.jodice@ssss.com	<b># Yrs in Business:</b> 100
Houston	TX	77095	<b>Fax:</b> 253/931-1175	<b>Web:</b> <a href="http://www.ssss.com">www.ssss.com</a>
US				<b># Employees:</b> 3000+

Stewart & Stevenson, Distributed Energy Solutions packages engine/generator sets for prime power and biogas applications. Stewart & Stevenson provides engineering, equipment, and construction services as well as operation and maintenance of power generation equipment.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### STM Power

Randy Thomas  
275 Metty Drive  
Ann Arbor MI 48103  
US

**Tel:** 610/323-4519  
**Ext:**  
**Fax:** 610/323-4870

**Email:** [thomas.randy@stmpower.com](mailto:thomas.randy@stmpower.com)  
**Web:** [www.stmpower.com](http://www.stmpower.com)

**# Yrs in Business:** 13  
**# Employees:** 65

STM Power is a designer and developer of commercial-scale external combustion (Stirling cycle) engines.

### Canada Composting Inc.

Kevin Matthews  
390 Davis Drive, Suite 301  
Newmarket Ontario L3Y 7T8  
Canada

**Tel:** 905/830-1160  
**Ext:**  
**Fax:** 905-830-0416

**Email:** [ccikevin@attglobal.net](mailto:ccikevin@attglobal.net)  
**Web:** [www.canadacomposting.com](http://www.canadacomposting.com)

**# Yrs in Business:** 8  
**# Employees:** 8

Canada Composting Inc. is a private company that holds the exclusive rights to the BTA-Process throughout Canada and the United States. The BTA-Process technology employs anaerobic digestion for the production of biogas and compost from organic waste.

### Dresser ROOTS

John Parrish  
2135 Hwy 6 South  
Houston TX 77077  
US

**Tel:** 281/966-4700  
**Ext:**  
**Fax:** 281/966-4309

**Email:** [roots@dresser.com](mailto:roots@dresser.com)  
**Web:** [www.rootsblower.com](http://www.rootsblower.com)

**# Yrs in Business:** 148  
**# Employees:**

Dresser ROOTS Blowers and Compressors manufactures and sells positive displacement rotary lobe blowers and vacuum pumps, as well as a complete line of centrifugal compressors. The company's product line covers from 5 to 300,000 cfm with differential pressures of up to 30 PSI and vacuum levels of up to 28" Hg.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### Kompogas AG

W. Schmid		<b>Tel:</b> 41 1 809 71 00		
Rohrstrasse 36		<b>Ext:</b>	<b>Email:</b> <a href="mailto:info@kompogas.ch">info@kompogas.ch</a>	<b># Yrs in Business:</b> 12
Glattbrugg	CH-8152	<b>Fax:</b> 41 1 809 71 10	<b>Web:</b> <a href="http://www.kompogas.ch">www.kompogas.ch</a>	<b># Employees:</b> 50
Switzerland				

Kompogas AG has developed an anaerobic process for the fermentation of biogenous yard and kitchen waste combined with energy production. Waste recycling using the Kompogas process offers numerous advantages. The end products obtained from the process include CO<sub>2</sub>-neutral renewable energy (biogas), as well as high-quality compost and liquid fertilizer. The biogas recovered provides energy in the form of heat, electric power, and vehicle fuel.

### MWH Energy Solutions

Stephen Chippas		<b>Tel:</b> 630/836-8977		
27755 Diehl Road		<b>Ext:</b>	<b>Email:</b> <a href="mailto:EnergySolutions@mwhglobal.com">EnergySolutions@mwhglobal.com</a>	<b># Yrs in Business:</b> 2
Warrenville	IL 60555	<b>Fax:</b> 630/836-8959	<b>Web:</b> <a href="http://www.mwhglobal.com">www.mwhglobal.com</a>	<b># Employees:</b> 6
US				

MWH Energy Solutions has extensive experience in the recovery, cleaning, and combustion of biogas. This expertise includes wastewater treatment plants, landfills, and agricultural applications. MWH can provide complete turnkey services including planning, design, procurement, construction, financing, and O&M services.

### Norton Environmental Equipment, Ltd.

Steven Viny		<b>Tel:</b> 216/447-0070		
6200 Rockside Woods Blvd.		<b>Ext:</b> 148	<b>Email:</b> <a href="mailto:sviny@daladgroup.com">sviny@daladgroup.com</a>	<b># Yrs in Business:</b> 3
Independence	OH 44131	<b>Fax:</b> NA	<b>Web:</b>	<b># Employees:</b> 6
US				

Norton Environmental Equipment Company, Ltd. is the exclusive distributor for Komptech composting equipment in North America. Komptech's BFSC system is for digesting on-farm waste, including compost production and gas recovery. Several such systems have been installed and are operating successfully in Europe.

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## Industry Directory for On-Farm Biogas Recovery Systems

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### Vaughan Company, Inc.

Mike Panther		<b>Tel:</b> 360/249-4042		
364 Monte-Elma Road		<b>Ext:</b>	<b>Email:</b> mpanther@chopperpumps.com	<b># Yrs in Business:</b> 42
Montesano	WA	<b>Fax:</b> 360/249-6155	<b>Web:</b> <a href="http://www.chopperpumps.com">www.chopperpumps.com</a>	<b># Employees:</b> 57
US	98563			

Vaughan Company, Inc. designs and builds complete hydraulic mixing systems for methane digesters and sludge-storage tanks. Each digester mixing system is supplied with a mixing guarantee. Vaughan Company, Inc. also manufactures a complete line of heavy-duty chopper pumps for sludge and manure with high concentrations of solids. The company has been a leader in solids-handling technology for over 40 years. Each pump is backed with a non-clog performance guarantee.

### Equipment Suppliers/Distributors: Tanks

#### Engineered Storage Products Company

Dave Friederick		<b>Tel:</b> 815/756-1551		
345 Harvestore Drive		<b>Ext:</b>	<b>Email:</b> dfriederick@engstorage.com	<b># Yrs in Business:</b> 52
Dekalb	IL	<b>Fax:</b> 815/756-1659	<b>Web:</b> <a href="http://www.slurrystore.com">www.slurrystore.com</a>	<b># Employees:</b> 143
US	60115			

Engineered Storage Products Company (E.S.P.C.) performs feasibility assessments and designs and installs biogas systems. E.S.P.C. has designed biogas systems for seven farms in the United States and 10 farms in Europe. Representative projects include: 1) Huntington Dairy, a 600-cow dairy in Cooperstown, New York; and 2) University of Florida, a 500-cow dairy in Gainesville, Florida.

#### Alliant Energy

Duane Hanusa		<b>Tel:</b> 608/742-0888		
2777 Columbia Drive		<b>Ext:</b>	<b>Email:</b> duanehanusa@alliantenergy.com	<b># Yrs in Business:</b> 5
Portage	WI	<b>Fax:</b> 608/742-0890	<b>Web:</b> <a href="http://www.alliantenergy.com">www.alliantenergy.com</a>	<b># Employees:</b> 7,200
US	53901-9483			

Headquartered in Madison, Wisconsin, Alliant Energy Corporation is a growing energy-service provider with operations in the United States and abroad. The company provides electric, natural gas, water, and steam services to nearly three million customers worldwide.

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### Chevron Energy Solutions

Felix Lopez; Dennis Potter  
345 California Street  
San Francisco CA 94104  
US

**Tel:** 415/733-4531

**Ext:**

**Email:** lofe@chevrontexaco.com

**Fax:** 415-733-4954 **Web:** [www.chevronenergy.com](http://www.chevronenergy.com)

**# Yrs in Business:** 3

**# Employees:** 150

Chevron Energy Solutions' initial focus is on large dairies and waste treatment plants in California's Central Valley. Chevron Energy Solutions also supplies fuel cells, cogeneration, and microturbines, combined with other energy services.

### Prime Power, Inc.

Guy Hallgren; Joel Moore  
535 South Madison Avenue  
Watkins Glen NY 14891  
US

**Tel:** 607/535-5407

**Ext:**

**Email:** GQHallgren@Primepwr.com

**Fax:** 607/535-8048 **Web:** [primepwr.com](http://primepwr.com)

**# Yrs in Business:** 4

**# Employees:** 3

Prime Power, Inc. provides complete service in the design, development, and construction of anaerobic digester systems and other alternative energy solutions. Prime Power is headquartered in Watkins Glen, New York, and is owned and operated by Joel Moore and Guy Hallgren. They have over 35 years combined experience in electric and gas engineering and construction.

### Publishers

#### BioCycle Magazine

Jerry Goldstein  
419 State Avenue  
Emmaus PA 18049  
US

**Tel:** 610/967-4135

**Ext:** 25

**Email:** biocycle@jgpress.com

**Fax:** 610/967-1345 **Web:** [www.biocycle.net](http://www.biocycle.net)

**# Yrs in Business:** 25

**# Employees:** 10

Published since 1960, BioCycle, Journal of Composting & Organics Recycling is recognized as the foremost magazine on using organic residuals to maximum advantage. The journal explores topics ranging from improving the health of soils and crops to producing renewable energy in the form of methane and alcohol fuels. In addition, the editors of BioCycle have published two special reports on renewable energy: "The BioCycle Guide to Anaerobic Digestion" and "Renewable Energy from Organics Recycling." Both reports are available from The JG Press, Inc., publisher of BioCycle. Publications can be ordered online at [www.biocycle.net](http://www.biocycle.net).

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### Universities

#### University of Florida, Soil and Water Science Department

Dr. Ann C. Wilkie	<b>Tel:</b> 352/392-8699			
P.O. Box 110960 University of Florida	<b>Ext:</b>	<b>Email:</b> <a href="mailto:acwilkie@mail.ifas.ufl.edu">acwilkie@mail.ifas.ufl.edu</a>	<b># Yrs in Business:</b>	NA
Gainesville FL 32611-0960	<b>Fax:</b> 352/392-8699	<b>Web:</b> <a href="http://soils.ifas.ufl.edu/">http://soils.ifas.ufl.edu/</a>	<b># Employees:</b>	NA
US				

Dr. Wilkie is an associate professor with the Soil and Water Science Department at the University of Florida and an environmental microbiologist. She investigates and develops bioremediation techniques for agricultural and industrial wastes, with emphasis on the microbial and environmental factors influencing biodegradation. Dr. Wilkie specializes in anaerobic microbiology and in the practical application of anaerobic digestion technologies for waste treatment, odor control, and biogas production.

<b><i>25 Year, 24 Hour Storm Event:</i></b>	The rainfall event with a probable recurrence interval of once in 25 years with a duration of 24 hours, as defined by the National Weather Service in technical Paper Number 40, "Rainfall Frequency Atlas of the United States:", May 1961, and subsequent amendments.
<b><i>Aerobic Bacteria:</i></b>	Bacteria that require free elemental oxygen to sustain life.
<b><i>Aerobic:</i></b>	Requiring, or not destroyed by, the presence of free elemental oxygen.
<b><i>AgSTAR:</i></b>	A voluntary federal program that encourages the use of effective technologies to capture methane gas, generated from the decomposition of animal manure, for use as an energy resource.
<b><i>Ally:</i></b>	Companies in the agricultural and energy industries that assist AgSTAR Partners by developing and distributing up-to-date technology for methane recovery systems.
<b><i>Anaerobic:</i></b>	Requiring, or not destroyed by, the absence of air or free oxygen.
<b><i>Anaerobic Bacteria:</i></b>	Bacteria that only grow in the absence of free elemental oxygen.
<b><i>Anaerobic Lagoon:</i></b>	A treatment or stabilization process that involves retention under anaerobic conditions.
<b><i>Anaerobic:</i></b>	A tank or other vessel for the decomposition of organic matter in the absence of elemental oxygen.
<b><i>Anaerobic Digestion:</i></b>	The degradation of organic matter including manure brought about through the action of microorganisms in the absence of elemental oxygen.
<b><i>Bacteria:</i></b>	A group of universally distributed and essentially unicellular microscopic organisms lacking chlorophyll.
<b><i>Barn:</i></b>	A totally or partially enclosed structure where animals are confined.
<b><i>Best Management Practice (BMP):</i></b>	A practice or combination of practices found to be the most effective, practicable (including economic and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.
<b><i>Biogas:</i></b>	Gas resulting from the decomposition of organic matter under anaerobic conditions. The principal constituents are methane and carbon dioxide.
<b><i>Biomass:</i></b>	Plant materials and animal wastes used especially as a source of fuel.
<b><i>Boar:</i></b>	An uncastrated male pig.
<b><i>British Thermal Unit (BTU):</i></b>	The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One cubic foot of biogas typically contains about 600 to 800 BTUs of heat energy. By comparison, one cubic foot of natural gas contains about 1,000 BTUs.
<b><i>Bull:</i></b>	A mature (approximately 24 months of age or older) uncastrated male dairy or beef animal.
<b><i>Calf:</i></b>	An immature dairy or beef animal up to approximately six months of age.
<b><i>Carbohydrates:</i></b>	Any of various compounds of carbons, hydrogen, and oxygen (e.g., sugars, starches, and celluloses), which are generally formed by green plants. Carbohydrates are a principal source of energy in animal feeds and are excreted if not utilized.
<b><i>Complete Mix Digester:</i></b>	A controlled temperature, constant volume, mechanically mixed vessel designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.

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<b><i>Composting:</i></b>	The biological decomposition and stabilization of organic matter under conditions which allow the development of elevated temperatures as the result of biologically produced heat. When complete, the final product is sufficiently stable for storage and application to land without adverse environmental effects.
<b><i>Confine:</i></b>	A confinement facility for swine animals.
<b><i>Cover Fraction:</i></b>	The fraction of the lagoon (0-100%) that is covered by an impermeable gas- and air-tight cover.
<b><i>Covered Lagoon Digester:</i></b>	An anaerobic lagoon fitted with an impermeable, gas- and air-tight cover designed to capture biogas resulting from the decomposition of manure.
<b><i>Cow:</i></b>	A mature female dairy or beef animal that has produced at least one calf.
<b><i>Cow-Dry:</i></b>	A mature cow in the period between the cessation of lactation and calving.
<b><i>Cow-Lac:</i></b>	A lactating dairy or beef cow.
<b><i>Dairy-Drylot:</i></b>	A dairy farm where cows are confined and fed in an open lot, also called a corral or paddock in some regions.
<b><i>Dairy-Free Stall:</i></b>	A dairy farm where cows are confined in a totally or partially enclosed structure but are not confined in individual stalls.
<b><i>Dairy-Tie Stall:</i></b>	A dairy farm where cows are confined in a totally or partially enclosed structure and are confined in individual stalls.
<b><i>Dairy-Stand-Alone-Heifer:</i></b>	A dairy operation that specializes in raising calves as dairy cow replacements.
<b><i>DDB Depreciation:</i></b>	Double declining balance (DDB) depreciation is an accelerated depreciation method in which first year depreciation is double the amount of straight-line depreciation.
<b><i>Demand charge:</i></b>	The peak kW demand during any quarter hour interval multiplied by the demand charge rate.
<b><i>Digester:</i></b>	A concrete vessel used for the biological, physical, or chemical breakdown of livestock and poultry manure.
<b><i>Discount rate:</i></b>	The interest rate used to convert future payments into present values.
<b><i>Down payment:</i></b>	The initial amount paid at the time of purchase or construction expressed as a percent of the total initial cost.
<b><i>Drylot:</i></b>	An enclosed, unpaved area where the animals can move about freely and where they can feed along a feed apron.
<b><i>Drystack:</i></b>	Solid or dry manure that is scraped from a barn, feedlane, drylot or other similar surface and stored in a pile until it can be utilized.
<b><i>Effluent:</i></b>	The discharge from an anaerobic digester or other manure stabilization process.
<b><i>Endorsers:</i></b>	Professional and trade associations, colleges and universities, institutions, and societies who support AgSTAR and encourage the use of renewable energy sources.
<b><i>Energy Charge:</i></b>	The energy charge rate times the total kWh of electricity used.
<b><i>Facultative:</i></b>	Living, active, or occurring in the presence or absence of free oxygen.
<b><i>Facultative Bacteria:</i></b>	Bacteria living in the presence or absence of free oxygen. Facultative bacteria are important in the decomposition of manure.

<b><i>FarmWare:</i></b>	A computerized decision support system that allows the evaluation of the costs and benefits of AgSTAR methane recovery systems.
<b><i>Fats:</i></b>	Any of numerous compounds of carbon, hydrogen, and oxygen that are glycerides of fatty acids, the chief constituents of plant and animal fat, and a major class of energy-rich food. "Fats are a principal source of energy in animal feeds and are excreted if not utilized."
<b><i>Feed Apron:</i></b>	A paved or hard surface along one side of a drylot where feed is provided to the animals.
<b><i>Feeder Pig:</i></b>	A pig from about 60 pounds to market weight.
<b><i>Finisher:</i></b>	A swine animal finished for market.
<b><i>Fixed Film Digester:</i></b>	An anaerobic digester in which the microorganisms responsible for waste stabilization and biogas production are attached to some inert medium.
<b><i>Flushing System:</i></b>	A manure collection system that collects and transports manure using water.
<b><i>Freeboard:</i></b>	The distance between the highest possible wastewater level in a manure storage/treatment structure and the top of the structure. Freeboard is an important design parameter in designing lagoons, ponds, storage basins, digesters, and other manure storage and treatment structures.
<b><i>Gilt:</i></b>	A female swine that has not produced pigs and has not reached an evident stage of pregnancy.
<b><i>Greenhouse Gas:</i></b>	An atmospheric gas, which is transparent to incoming solar radiation but absorbs the infrared radiation emitted by the Earth's surface. The principal greenhouse gases are carbon dioxide, methane, and CFCs.
<b><i>Grower:</i></b>	An immature male or female swine animal managed between weaning and finishing weights.
<b><i>Heifer:</i></b>	A female dairy or beef animal that has not produced a calf.
<b><i>Hydraulic Retention Time (HRT):</i></b>	The average length of time any particle of manure remains in a manure treatment or storage structure. The HRT is an important design parameter for treatment lagoons, covered lagoon digesters, complete mix digesters, and plug flow digesters.
<b><i>Inflation Rate:</i></b>	The annual rate of increase in costs or sales prices in percent.
<b><i>Influent:</i></b>	The flow into an anaerobic digester or other manure stabilization process.
<b><i>Internal Rate of Return (IRR):</i></b>	The discount rate that makes the NPV of an income stream equal to zero.
<b><i>Kilowatt (kW):</i></b>	One thousand watts (1.341 horsepower).
<b><i>Kilowatt Hour (kWh):</i></b>	A unit of work or energy equal to that expended by one kilowatt in one hour or to 3.6 million joules. A unit of work or energy equal to that expended by one kilowatt in one hour (1.341 horsepower-hours).
<b><i>Lagoon:</i></b>	Any large holding or detention pond, usually with earthen dikes, used to contain wastewater while sedimentation and biological treatment or stabilization occur.
<b><i>Land Application:</i></b>	Application of manure to land for reuse of the nutrients and organic matter for their fertilizer value.
<b><i>Liquid Manure</i></b>	Manure having a total solids content of no more than five percent.

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<b><i>Loading Rate:</i></b>	A measure of the rate of volatile solids (VS) entry into a manure management facility with methane recovery. Loading rate is often expressed as pounds of VS/1000 cubic feet.
<b><i>Loan Rate:</i></b>	The percent of the total loan amount paid per year.
<b><i>Manure:</i></b>	The fecal and urinary excretions of livestock and poultry.
<b><i>Marginal Tax Rate:</i></b>	The percent of the methane recovery project net income to be paid in taxes.
<b><i>Memorandum of Understanding (MOU):</i></b>	An agreement between AgSTAR Partners, Allies, and Endorsers and the EPA stating the responsibilities and commitments agreed to by both parties.
<b><i>Mesophilic:</i></b>	Operationally between 80°F and 100°F (27°C and 38°C).
<b><i>Methane:</i></b>	A colorless, odorless, flammable gaseous hydrocarbon that is a product of the decomposition of organic mater. Methane is a major greenhouse gas. Methane is also the principal component of natural gas.
<b><i>Methane Project Lifetime:</i></b>	The period of time during which the project is installed and completely paid for.
<b><i>Methane Recovery Lagoon:</i></b>	See covered lagoon digester.
<b><i>Minimum Treatment Volume:</i></b>	The minimum volume necessary for the design HRT or loading rate.
<b><i>Mix Tank:</i></b>	A control point where manure is collected and added to water or dry manure to achieve the required solids content for a complete mix or plug flow digester.
<b><i>Natural Gas:</i></b>	A combustible mixture of methane and other hydrocarbons used chiefly as a fuel.
<b><i>Net Present Value (NPV):</i></b>	The present value of all cash inflows and outflows of a project at a given discount rate over the life of the project.
<b><i>Nonpoint Source Pollution:</i></b>	Pollution resulting from intermittent discharges of pollutants from diffuse sources and is in transit over land before entering a water body.
<b><i>NPV Payback:</i></b>	The number of years it takes to pay back the capital cost of a project calculated with discounted future revenues and costs. Profitable projects will have an NPV Payback value less than or equal to the lifetime of the project.
<b><i>Nursery:</i></b>	An immature male or female swine animal managed between birth and growing/finishing.
<b><i>Nursery Pig:</i></b>	A weaned pig up to about 60 pounds live weight.
<b><i>Nutrients:</i></b>	A substance required for plant or animal growth. The primary nutrients required by plants are nitrogen, phosphorus, and potassium. The primary nutrients required by animals are carbohydrates, fats, and proteins.
<b><i>Operating Volume:</i></b>	The volume of the lagoon needed to hold and treat the manure influent and the rain-evap volume.
<b><i>Parlor:</i></b>	Facility where lactating cows are managed before, during, and after milking.
<b><i>Partner:</i></b>	A livestock producer who signs a Memorandum of Understanding (MOU) with the U.S. EPA and agrees to survey his/her facility and install methane recovery systems where profitable within 3 years.
<b><i>Pasture:</i></b>	An open area where the animals may roam freely.

<b><i>Payback Years:</i></b>	The number of years it takes to pay back the capital cost of a project.
<b><i>pH:</i></b>	A measure of acidity or alkalinity. The pH scale ranges from zero to 14, with a value of 7 considered neutral. The lower a value, the higher the acidity, and the higher the value, the higher the alkalinity.
<b><i>Piglet:</i></b>	A nursing pig.
<b><i>Plug Flow Digester:</i></b>	A constant volume, flow-through, controlled temperature biological treatment unit designed to maximize biological treatment, methane production, and odor control as part of a manure management facility with methane recovery.
<b><i>Point Source Pollution:</i></b>	Pollution entering a water body from a discrete conveyance such as a pipe or ditch.
<b><i>Process Water:</i></b>	Water used in the normal operation of a livestock farm. Process water includes all sources of water that may need to be managed in the farm's manure management system.
<b><i>Proteins:</i></b>	Any of numerous naturally occurring extremely complex combinations of amino acids containing the elements carbon, hydrogen, nitrogen, and oxygen. Proteins in animal feeds are utilized for growth, reproduction, and lactation and are excreted if not utilized.
<b><i>Psychrophilic:</i></b>	Operationally between 54°F and 64°F (12°C and 18°C).
<b><i>Pull Plug Pit:</i></b>	A series of one or more pits where manure is collected until it is utilized or transferred to a storage or treatment structure.
<b><i>Rain-Evap Volume:</i></b>	The volume of the lagoon needed to hold the average rainfall on the surface and any watershed runoff minus the average evaporation at the surface.
<b><i>Scrape System:</i></b>	Collection method that uses a mechanical or other device to regularly remove manure from barns, confine buildings, drylots, or other similar areas where manure is deposited.
<b><i>Separator:</i></b>	A mechanical device or gravity settling basin that separates manure into solid and liquid fractions.
<b><i>Settling Basin:</i></b>	A basin designed to separate solid and fibrous material in the manure from the liquid portion.
<b><i>Sideslope:</i></b>	The slope of a lagoon embankment, often expressed as the ratio of the horizontal displacement and vertical displacement.
<b><i>Simple Payback:</i></b>	The number of years it takes to pay back the capital cost of a project calculated without discounting future revenues or costs.
<b><i>Sludge Volume:</i></b>	Volume to allow for sludge accumulation in a manure storage or treatment structure. Sludge volume is an important design parameter for manure storage and treatment structures.
<b><i>Slurry (Semi-solid) Manure:</i></b>	Manure having a total solids content between five and ten percent.
<b><i>Solids Manure:</i></b>	Manure having a total solids content exceeding 10 percent.
<b><i>Sow:</i></b>	A female pig that has produced at least one litter of piglets.
<b><i>Storage Pond:</i></b>	An earthen basin designed to store manure and wastewater until it can be utilized. Storage ponds are not designed to treat manure.
<b><i>Storage Tank:</i></b>	A concrete or metal tank designed to store manure and wastewater until it can be utilized. Storage tanks are not designed to treat manure.

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# Glossary

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<b><i>Storm Runoff:</i></b>	Manure contaminated rainfall which must be stored and utilized on the farm and may not be discharged into rivers, streams, lakes, or other bodies of water.
<b><i>Straight-Line Depreciation:</i></b>	Depreciation per year equals the total facility cost divided by the years of depreciation (usually the facility lifetime).
<b><i>Supplemental Heat:</i></b>	Heat added to complete mix and plug-flow digesters to maintain a constant operating temperature to increase rates of waste stabilization and biogas production.
<b><i>Swine-Farrow-to-Finish:</i></b>	A swine operation where pigs are raised from birth to market weight.
<b><i>Swine-Farrow-to-Nursery:</i></b>	A swine operation where pigs are raised from birth to weaning.
<b><i>Swine-Farrow-to-Feeder:</i></b>	A swine operation where pigs are raised from birth to approximately 60 pounds live weight.
<b><i>Swine-Grow/Finish:</i></b>	A swine operation where feeder pigs are fed to market weight.
<b><i>Supplemental Heat:</i></b>	Additional heat added to complete mix and plug flow digester to maintain a constant operating temperature at which maximum biological treatment may occur.
<b><i>SYD Depreciation:</i></b>	Sum of Years' Digits (SYD) is a common accelerated depreciation method where the sum of the digits is the total of the numbers representing the years of depreciation (usually the facility lifetime).
<b><i>Thermophilic:</i></b>	Operationally between 110°F and 140°F (43°C and 60°C).
<b><i>Total Solids:</i></b>	The sum of dissolved and suspended solids usually expressed as a concentration or percentage on a wet basis.
<b><i>Utility Interconnection:</i></b>	The method of utilizing electricity produced from manure management facilities. Options include either (1) on farm first use then sale to utility or (2) sale to the utility then direct purchase.
<b><i>Volatile Solids:</i></b>	The fraction of total solids that is comprised primarily of organic matter.
<b><i>Volatilization:</i></b>	The loss of a dissolved gas, such as ammonia, from solution.
<b><i>Volumetric Loading Rate:</i></b>	The rate of addition per unit of system volume per unit time. Usually expressed as pounds of volatile solids per 1,000 cubic feet per day for biogas production systems.
<b><i>Watershed:</i></b>	A facility of berms, channels, or other devices to collect and hold manure contaminated runoff for up to a 25yr-24 hr storm event.
<b><i>Withdrawal Schedule:</i></b>	The fraction of the treated manure and water effluent that is withdrawn from the effluent storage facility each month.