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A Manual For Developing Biogas Systems at Commercial Farms in the United States

AgSTAR Handbook

Editors: K.F. Roos, J.B. Martin, Jr., and M.A. Moser

From the Editors

Rising energy prices in the 1970s triggered interest in using anaerobic digestion on U.S. farms to produce and use biogas from animal manures and resulted in the construction of several full-scale systems on commercial farms. Lessons learned during this developmental period (1975-1985) have resulted in improvements in design and operating parameters, equipment, and cost effectiveness.

The past decade has marked a period of significant expansion in the use of commercially proven biogas production and utilization systems by the dairy and swine industry. This growth in farm sector demand is due largely to improved technology and services, favorable renewable energy policies, federal and state incentive programs, and the "neighbor friendly" environmental advantages digester technologies provide as residential development expands in rural areas and regulatory pressures increase. There are currently about 70 animal waste digesters in operation on swine and dairy farms. Included are three centralized systems that provide waste treatment services to multiple farms. An additional 40 systems are in initial development stages and are planned to be operational in the next few years. These 120 systems have the potential to provide 25 MW of grid connected base load renewable energy while reducing greenhouse gases (methane) by about 40,000 metric tons per year—equivalent to 840,000 metric tons CO_2.

This handbook was developed to provide guidance for farms that are considering anaerobic digestion as a manure management option. When coupled with the use of FarmWare, the handbook is intended to provide a step by step methodology to assist users in making a preliminary technical, financial, and environmental assessment of a project's feasibility, based on farm size, current manure management practices, energy use profiles, and technology choice. The handbook has been printed as loose-leaf pages in a ring binder. This format was chosen because it facilitates updating material to keep pace with an expanding industry and technology base.

The first edition of the AgSTAR Handbook was prepared jointly by the U.S. EPA and ICF Inc. under contract #68-D4-0088. The editors also wish to acknowledge the following individuals for their contributions to the first edition:

First Edition Handbook reviewers and other contributors

Barry Kintzer, USDA-NRCS
Philip Lusk, Resource Development Associates
Ron Miner, Oregon State University
Don Stettler, USDA-NRCS
Peter Wright, Cornell University

From the Editors

FarmWare Version 2.0 reviewers and other contributors
Philip Lusk, Resource Development Associates
Richard Mattocks, Environomics, Inc.
Dave Moffit, USDA-NRCS
James Rickman, USDA-NRCS
Leland Saele, USDA-NRCS

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Richard Mattocks, Environomics, Inc.
Barry Kintzer, USDA-NRCS
Ann Wilkie, University of Florida

FarmWare Version 3.0 reviewers and other contributors
Kurt Roos, U.S. EPA
John Martin, Hall Associates
Douglas Williams, California Polytechnic State University

Introduction

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^3) 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

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.

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).

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.

Exhibit 1 Project Development Process

I. PROJECT FEASIBILITY ASSESSMENT
Ch. 2 - Preliminary Screening for Project Opportunities
Ch. 3 - Selecting a Gas Use Option
Ch. 4 - Technical and Economic Feasibility Assessment

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II. PROJECT IMPLEMENTATION
Ch. 5 - Securing an Energy Contract
Ch. 6 - Selecting a Consultant/Developer/Partner
Ch. 7 - Obtaining Project Financing
Ch. 8 - Permitting and Other Regulatory Issues

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.

Exhibit 2 How to use this Handbook - Quick Reference

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Part I. Project Feasibility Assessment	
SHOULD I CONSIDER BIOGAS RECOVERY AS AN OPTION FOR MY LIVESTOCK FACILITY? • How do I know if my facility is ready to operate a biogas system? • What information do I need to identify promising opportunities for a biogas system? • How do I know if I have the skills and support to operate a biogas system?	**2. Preliminary Screening for Project Opportunities** 2.1 Is Your Facility "Large", with Animals in Confinement? 2.2 Is Your Manure Management Compatible with Biogas Technology? 2.3 Is there a Use for Energy? 2.4 Can You Manage the Farm Effectively? 2.5 Initial Appraisal Results
CAN I USE BIOGAS AT MY FACILITY ? • What are the main uses of biogas? • How do I determine which biogas utilization option will maximize economic return? • What are the electricity generation options? How do I determine which option is suitable for my facility?	**3. Selecting a Gas Use Option** 3.1 Electricity Generation 3.2 Direct Combustion 3.3 Other Options
IS A BIOGAS SYSTEM TECHNICALLY AND FINANCIALLY FEASIBLE FOR MY FACILITY ? • How do I decide which biogas technology is appropriate for my livestock facility? • What information do I need to evaluate the technical and economic feasibility of a biogas project? • How do I compare the costs and revenues from a biogas project?	**4. Technical and Economic Feasibility Assessment** 4.1 Match a Digester to Your Facility's Waste Management Practices 4.2 Complete Evaluation Sheets 4.3 Enter Information into FarmWare 4.4 Evaluate Results
Part II. Project Implementation	
HOW DO I CLOSE THE UTILITY DEAL? • Do I need a utility deal? • How do I know if I'm getting the best possible deal? • How do I negotiate a "win/win" deal? • Where do I get help?	**5. Securing an Energy Contract** 5.1 Operation Modes 5.2 Interconnection Requirements 5.3 Who to Contact 5.4 What to Ask for 5.5 Elements of and Agreement 5.6 Why Negotiate and What to Watch Out For 5.7 Future Possibilities for Selling Electricity

OBJECTIVE	CHAPTER TO CONSULT
HOW DO I SELECT A CONSULTANT/DEVELOPER/PARTNER? • How do I know whether I need a consultant/developer/partner? • What should I look for in a consultant/developer/partner? • What should I include in a contract?	**6. Selecting a Consultant/Developer/Partner** 6.1 The Do-it-Yourself/Turnkey Decision 6.2 Selecting a Consultant/Consulting Firm 6.3 Selecting a Turn-Key Developer 6.4 Selecting a Partner 6.5 Preparing a Contract
HOW DO I GET FINANCING FOR THE PROJECT? • What are the sources of funding for biogas projects? • What do lenders/investors look for? • How do I evaluate different financing options?	**7. Obtaining Project Financing** 7.1 Financing: What Lenders/Investors Look For 7.2 Financing Approaches 7.3 Capital Cost of Different Financing Alternatives
WHAT DO I NEED TO KNOW ABOUT THE PERMITTING PROCESS? • What permits do I need? • How do I get these permits? • Do I need to worry about meeting air quality emission standards from IC engines?	**8. Permitting and Other Regulatory Issues** 8.1 The Permitting Process 8.2 Zoning and Permitting 8.3 Community Acceptance 8.4 Regulations Governing Air Emissions from Energy Recovery Systems
WHERE ARE BIOGAS SYSTEMS CURRENTLY OPERATIONAL?	**Appendix A:** http://www.epa.gov/agstar/projects/index.html
WHERE CAN I GET A LIST OF NRCS AND OTHER KEY CONTACTS?	**Appendix B:** http://offices.sc.egov.usda.gov/locator/app?agency=nrcs **and** http://www1.eere.energy.gov/biomass/state_regional.html
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Chapter 1 Overview of Biogas Technology

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.

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
Digestion Vessel	Deep Lagoon	Round/Square In/Above-Ground Tank	Rectangular In-Ground Tank	Above Ground Tank
Level of Technology	Low	Medium	Low	Medium
Supplemental Heat	No	Yes	Yes	No
Total Solids	0.5 - 3%	3 - 10%	11 - 13%	3%
Solids Characteristics	Fine	Coarse	Coarse	Very Fine
HRT* (days)	40 - 60	15+	15+	2-3
Farm Type	Dairy, Hog	Dairy, Hog	Dairy Only	Dairy, Hog
Optimum Location	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.

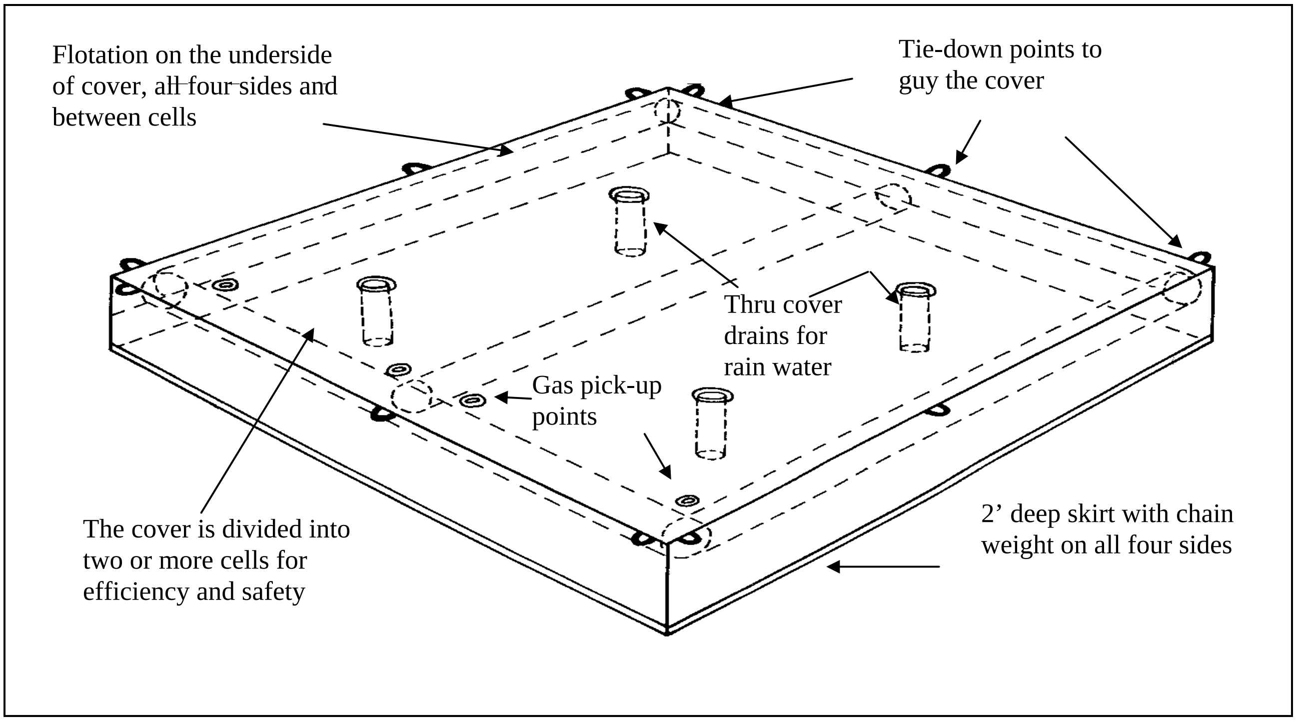
- **Plug Flow Digester:** Plug flow digesters are engineered, heated, rectangular tanks that treat scraped *dairy* manure with a range of 11 to 13 percent total solids. Swine manure cannot be treated with a plug flow digester due to its lack of fiber.

- **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^3. 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.

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.

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 face 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.

Chapter 2 Preliminary Screening for Project Opportunities

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Chapter 2 Preliminary Screening for Project Opportunities

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 <u>not</u> absolute. Smaller confined facilities could potentially support successful recovery projects, given certain site-specific and market conditions.

Note: "Large" is referred to here for purposes of biogas assessment, and does not pertain to any other agency definition or program.

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.

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 additional 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

Do you have at least 500 cows/steer or 2,000 pigs at your facility?	Yes ❑	No ❑
Are these animals in confinement all year round?	Yes ❑	No ❑
The average animal population does not vary by more than 20% in a year?		

If the answer is to all the above questions, your facility is in good shape. If the answer is 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 bio- 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.

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.

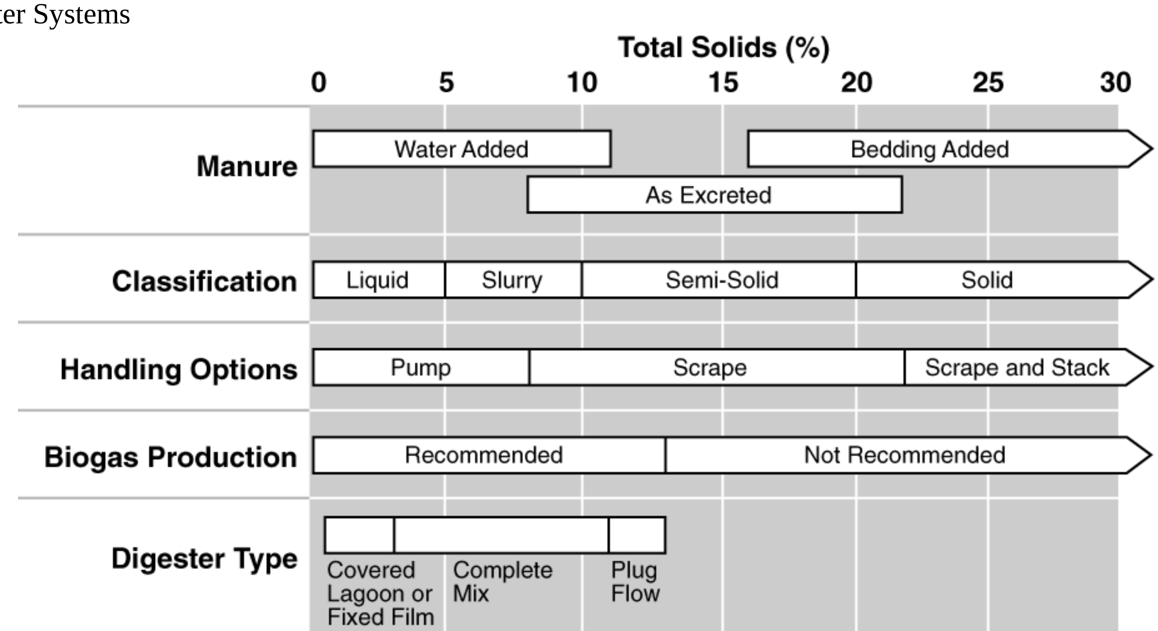
2-2.2 Is the Manure Collected at One Point?

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. Pretreatment 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



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

Do you collect manure as a liquid/slurry/semi-solid?	Yes ❑	No ❑
Is the manure collected and delivered to one common point?	Yes ❑	No ❑
Is the manure collected daily or every other day?	Yes ❑	No ❑
Is the manure sand relatively free of clumps of bedding and other material, such		

to all the above questions, manure management criterion is satisfied.
, to any of the questions, you may need to change your manure management routine.

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 livestock 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.** <u>There are key components of a digester system with which the owner must become familiar</u>. 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.** <u>System operation requires a time commitment</u>. Daily maintenance and monitoring of

Exhibit 2-4 Checklist for Energy Use

Are there on-site uses (e.g., heating, electricity, refrigeration) for the energy	Yes ❑ No ❑
Are there facilities nearby that could use the biogas?	
Are there electric power distribution systems in your area that could or do buy power from projects such as biogas recovery?	Yes ❑ No ❑
to any of the above questions, the energy use criterion is satisfied for initial screening purposes.	

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 decision 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

Is there a "screw driver friendly" person on the farm that can operate and maintain the technical equipment?	Yes ❑ No ❑
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 ❑ No ❑
Will this person be available to make repairs during high labor use events at the farm?	
Will the owner be overseeing system operations?	

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

Are there at least 500 cows/steers or 2,000 hogs in confinement at your facility year round?	Yes ❑	No ❑
Is your manure management compatible with biogas technology?	Yes ❑	No ❑
Can you use the energy?	Yes ❑	No ❑
Can you be a good operator?	Yes ❑	No ❑

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 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.

- **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.

Chapter 3 Selecting a Gas Use Option

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3-1.1 Electricity Generation System Components 2
3-1.2 Electricity Generation Options 3

3-2. Direct Combustion 4

3-2.1 Heating 4
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Exhibit 3-2 Typical Engine-Generator Set 3
Exhibit 3-3 Hot Water Mats Replace Heat Lamps in Farrowing Buildings for Additional Energy Savings 4

Chapter 3 Selecting a Gas Use Option

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.

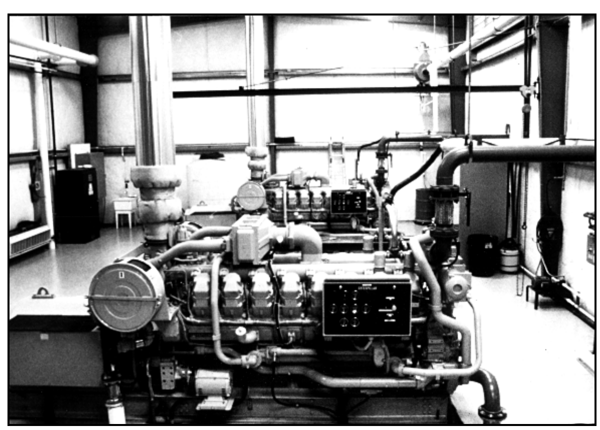
- **Parallel Power Production.** A parallel system is directly connected to the utility and matches the utility phasing, frequency and voltage so the farm produced electricity blends directly with the utility line power. A utility interconnection panel with safety relays is required to operate in parallel 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

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.

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

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.

Chapter 4 Technical and Economic Feasibility Assessment

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Chapter 4 Technical and Economic Feasibility Assessment

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.

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.

Chapter 4 Technical and Economic Feasibility Assessment

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.

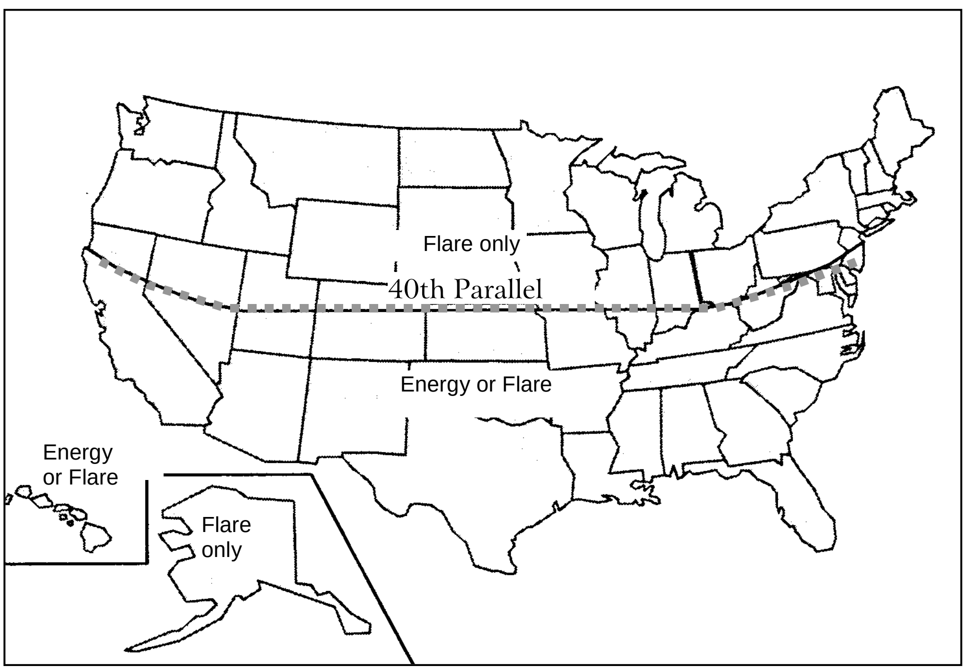
Complete mix digesters and plug flow digesters are usable in virtually all climates. Plug-flow digesters and complete-mix digesters use supplemental heat to ensure optimal temperature conditions in the 95° to 130°F range (35° to 55°C). Capturing waste heat from a generator set is the preferred method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

Exhibit 4-1 Covered Lagoons for Energy Recovery – Locations for Energy Production Generally Fall Below the 40th 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
Source: NRCS, *Agricultural Waste Management Field Handbook*, 1998.	

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 total 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

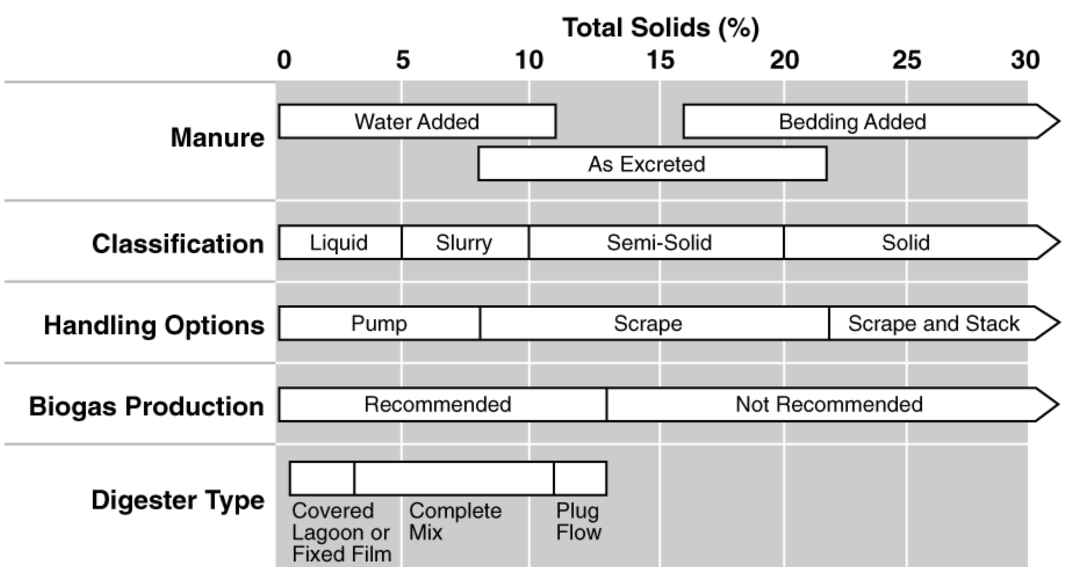


Exhibit 4-4 Matching a Digester to Your Facility

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 40th parallel and cold is the region above the 40th parallel (see Exhibit 4-1).
* These ratios are default estimates used in FarmWare.

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 completed 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.

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

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

________dry cow

________dairy heifer

________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

	(1)	(2)		(3)		(4)
Building	**Number of Flush Tanks in All Buildings**	**Gallons of Recycle Water per Tank**	**Gallons of Fresh Water per Tank**		**OR**	**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

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

Pull Plug and Pit Recharge Barns

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

Chapter 5 Securing an Energy Contract

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Chapter 5 Securing an Energy Contract

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.

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.

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.

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.

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 Biogas 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.

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.

Chapter 6 Selecting a Consultant/Developer/ Partner

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Chapter 6 Selecting a Consultant/Developer/Partner

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.

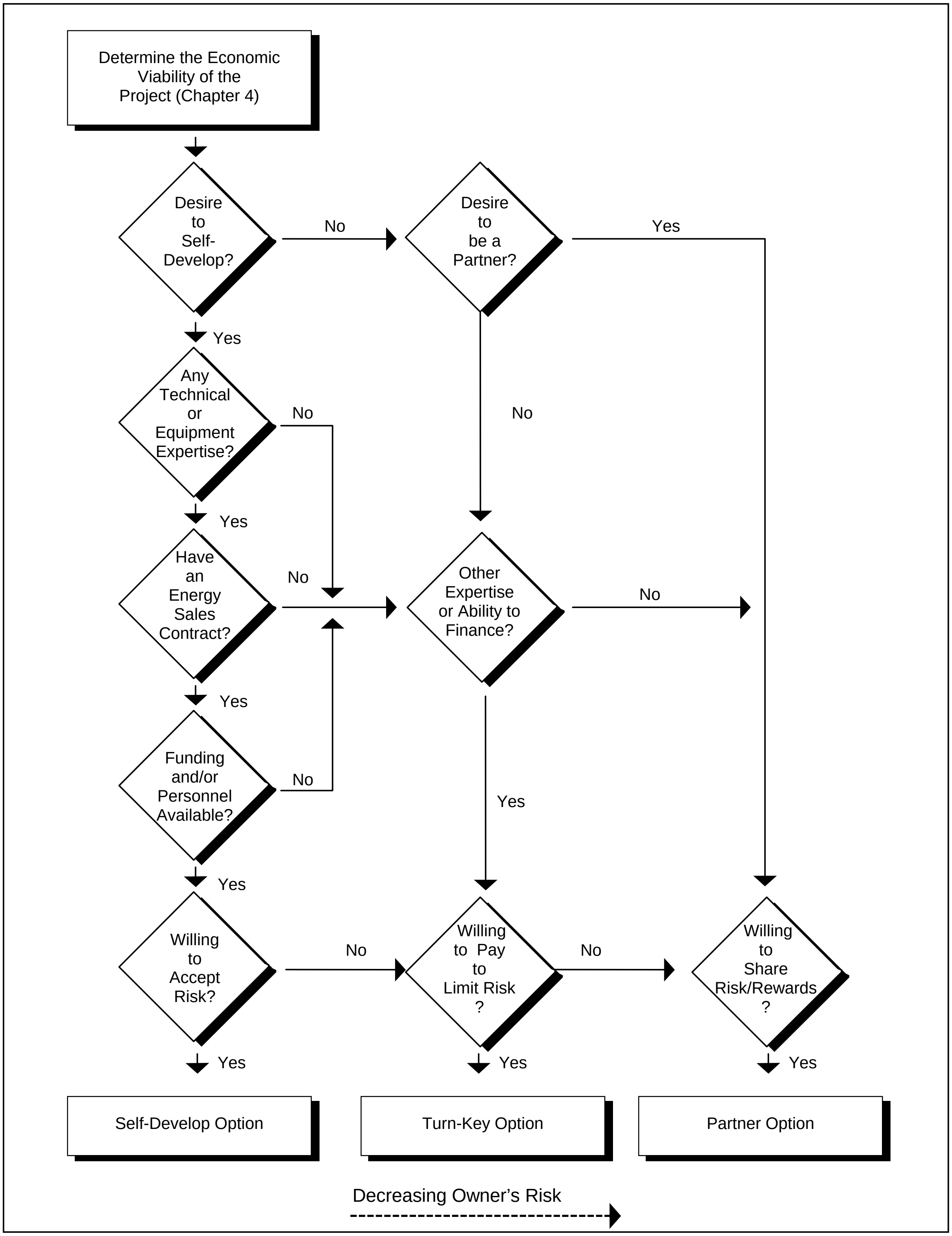
Exhibit 6-1 illustrates the process of determining the best development approach. As it indicates, in cases where the owner wants to be involved in the project development process, a number of issues must be considered. These issues are discussed in the following sections.

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;

Exhibit 6-2 Project Development Tasks

- <u>Determine Biogas Supply</u> 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.
- <u>Scope Out the Project</u> 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.
- <u>Conduct Feasibility Analysis</u> Feasibility analysis includes detailed technical and economic calculations to demonstrate the technical feasibility of the project and estimate project revenues and costs.
- <u>Select Equipment</u> Based on the results of the feasibility analysis, primary equipment is selected and vendors are contacted to assess price, performance, schedule, and guarantees.
- <u>Create a Financial Pro Forma</u> A financial pro forma is usually created to model the cash flows of a project and to predict financial performance.
- <u>Negotiate the Utility Agreement</u> The terms of the agreement must be negotiated with the purchasing electric utility.
- <u>Obtain Environmental and Site Permits</u> All required environmental permits and site permits/licenses must be acquired.
- <u>Gain Regulatory Approval</u> Some power projects must obtain approval from state regulators or certification by the Federal Energy Regulatory Commission (FERC).
- <u>Secure Financing</u> All the tasks above are needed to determine economic viability to allow financiers to loan money for the project.
- <u>Contract with Engineering, Construction, Equipment Supply Firms</u> 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.

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.

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 online 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.

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 manager 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.

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.

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

Chapter 7 Obtaining Project Financing

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Chapter 7 Obtaining Project Financing

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.

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.

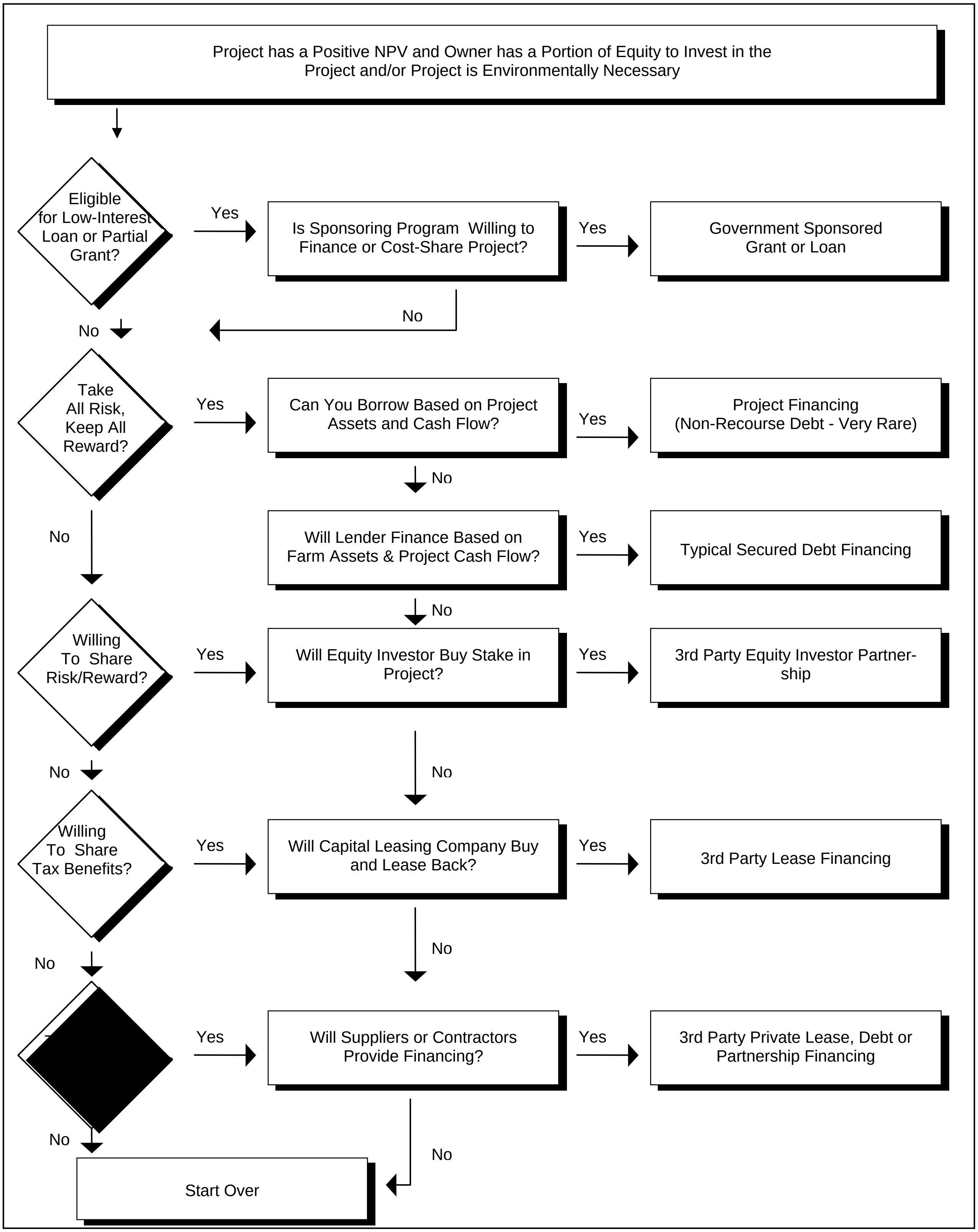
7-2. Financing Approaches

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.

Exhibit 7-1 Addressing Biogas Project Risks

Risk Category	Risk Mitigation Measure
Biogas Production Potential	• Use FarmWare to model gas production over time • Hire expert to report on gas production potential • Provide for back-up fuel if necessary
Construction	• Execute fixed-price turn-key contracts • Include monetary penalties for missing schedule • Establish project acceptance standards, warranties • Be sure the project conforms to NRCS standards
Equipment performance	• Select proven designer, developer, and technology • Design for biogas Btu content • Get performance guarantees, warranties from vendors • Select and train qualified operators on farm
Environmental permitting	• Obtain permits prior to financing (waste management, building)
Community acceptance	• Obtain zoning approvals • Demonstrate community support
Utility agreement	• Have signed contract with local utility • Make sure all aspects are covered • Get sufficient term to match debt repayment schedule • Confirm interconnection point, access, requirements • Make sure on-line date is achievable • Include force majeure provisions in agreement
Financial performance	• Create financial pro forma • Calculate cash flows, debt coverages • Commit equity to the project • Ensure positive NPV • Maintain working capital, reserve accounts • Budget for major equipment overhauls

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 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 installed 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 repaid 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. Project 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.

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.

Chapter 8 Permitting and Other Regulatory Issues

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Chapter 8 Permitting and Other Regulatory Issues

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.

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.

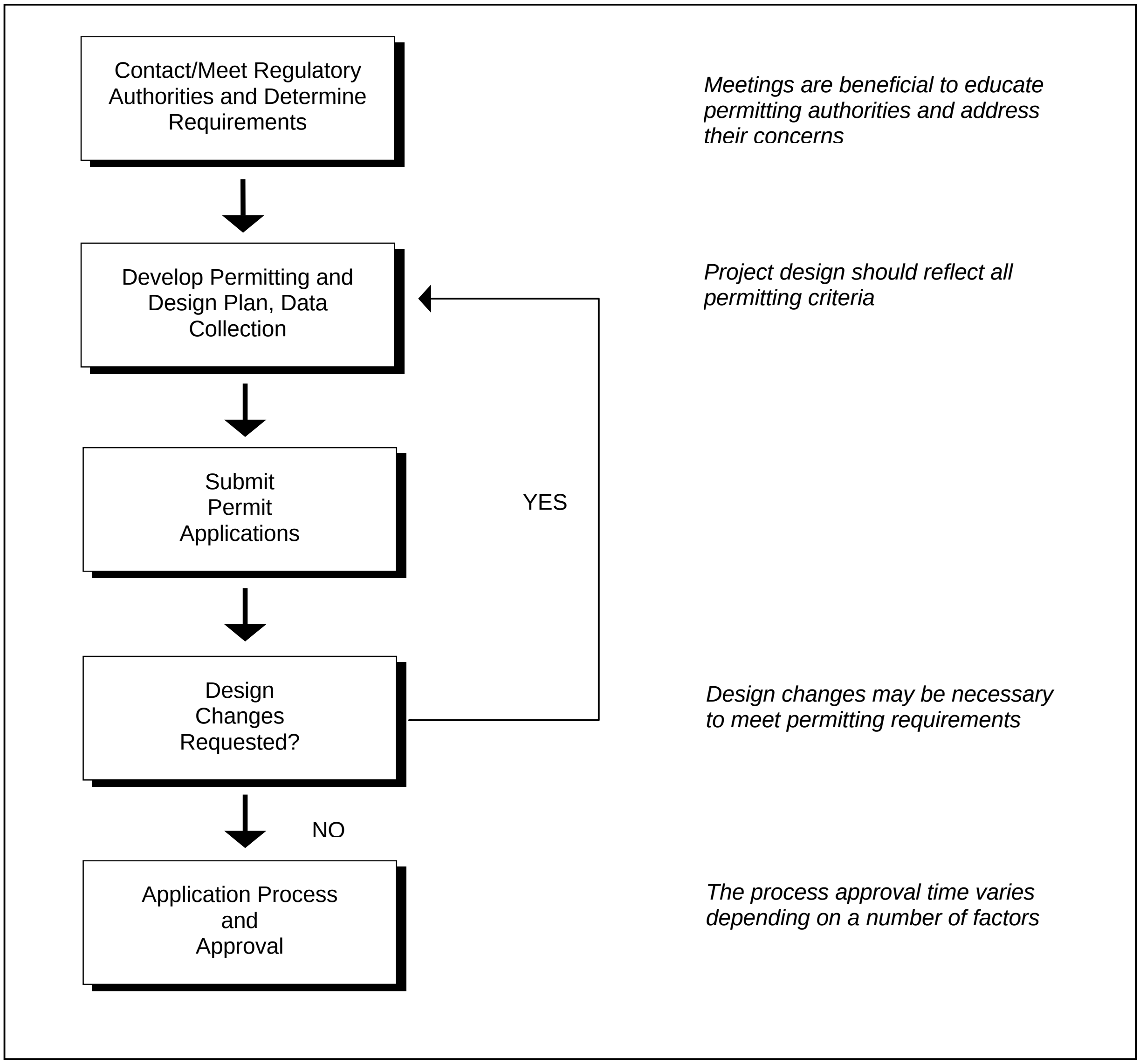
- **Step 4. Negotiate design changes with regulators in order to meet requirements**. Permitting processes sometimes provide opportunities to negotiate with regulators. If negotiation is allowed, it may take into account technical as well as economic considerations.

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 located 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.

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.

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.

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 Ambient 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 nonattainment 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_x Emissions from Energy Conversion

Combustion of biogas -- in an engine, turbine, or boiler -- generates nitrogen oxides (NO_x). For biogas combustion sources, NO_x 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_x 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 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 NO_x emissions than a comparable naturally aspirated engine. In recent years, manufacturers have developed engines with very low NO_x emissions.

When internal combustion engines are used in conventional natural gas applications, catalysts can be used to reduce 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 NO_x emissions.

Turbines and Boilers

With modern designs, gas-fired boilers and turbines emit levels of 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 SO_x Emissions from Energy Conversion

Combustion of biogas also can generate sulfur oxides (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.