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.

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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 <u>not</u> 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

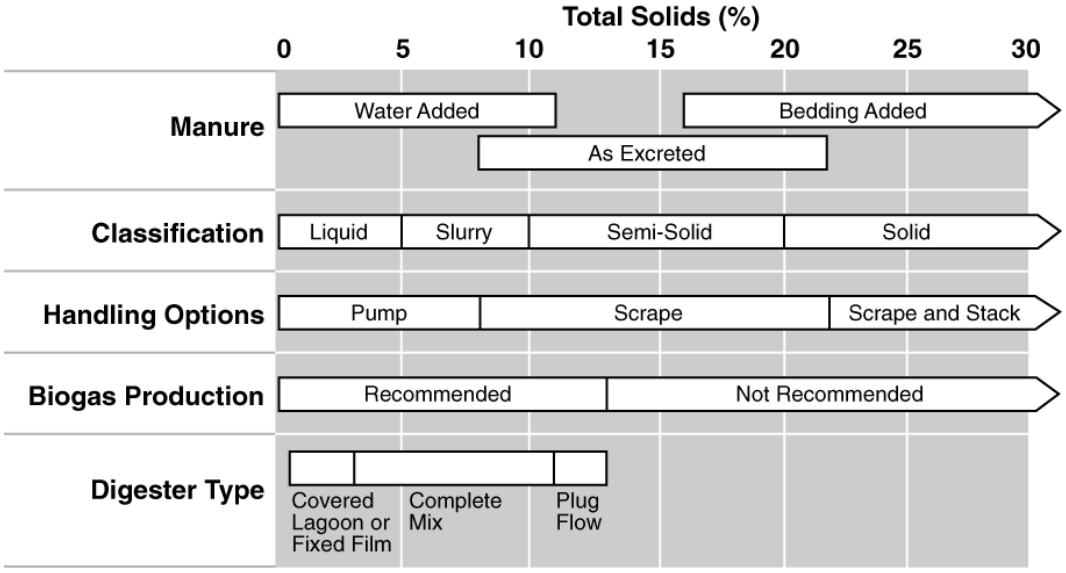

Exhibit 4-4 Matching a Digester to Your Facility

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.

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4-2. Complete Evaluation Forms

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

Each form contains the following five sections:

1. **Climate Information.** Enter the location (state and county) of the facility.

2. **Farm Type.** Enter the farm type, farm size, manure collection method, and manure treatment method.

3. **Livestock Population.** Enter the number of animals on the farm by animal type.

4. **Manure Management.** Enter information on the manure management routine of the farm.

5. **Energy Information.** Enter the overall energy rates, by season, as well as the monthly breakdown of electricity and propane costs. Appendix G contains a sample letter to a utility requesting a monthly billing history and rate schedules and should be submitted for accurate figures.

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

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

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