



# COMPLETING A SUCCESSFUL FEASIBILITY STUDY FOR AN ANAEROBIC DIGESTION PROJECT

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FS292E

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## Introduction

Prior to the 1990s, dairy producers in the United States who were interested in anaerobic digestion could still build anaerobic digesters with their own equipment and labor. A producer may have been attracted to the idea by the prospect of reducing manure odors, saving some money producing power, and using the digested solids for bedding.

Today, anaerobic digesters require significant up-front expenditures (U.S. EPA AgSTAR 2012). As the cost and complexity of anaerobic digesters has grown, so has the demand for analysis of the technical systems and the financial costs and benefits. Projects often rely on a number of different funding sources, including private funding, grants, loan guarantees, industrial bonds, and other cost-sharing agreements—and many of the parties involved in these projects may require documentation and evidence of the economic viability of the project (U.S. EPA AgSTAR 2012; U.S. EPA AgSTAR 2015). These studies are commonly referred to as feasibility studies.

The feasibility study can be thought of as a decision tool—a way to analyze the pros and cons of undertaking a project. The tool can come in any of several different forms depending on the scope of the potential project. The feasibility study can be structured broadly, say to compare different opportunities in a geographic area, or be more focused, say to compare a single option for one project.

Though a feasibility study for a large anaerobic digestion project is often completed by an outside consultant, there are many other stakeholders, including farmers, project developers, support professionals, and others, who need to be able to evaluate its quality—whether in selecting a consultant to complete a feasibility study, or in understanding and using the output from a feasibility study. This fact sheet looks at different aspects of feasibility studies—including outlines, guidance, cautions, and recommendations—with an eye toward improving the preparation, evaluation, and use of feasibility studies in the development of successful anaerobic digestion projects. Because there are many existing resources that discuss general feasibility studies, this publication focuses on the areas of feasibility studies that tend to be common for livestock-based anaerobic digestion projects.

*This factsheet is part of the Anaerobic Digestion System Series and assumes a basic familiarity with anaerobic digestion systems. Basic information about anaerobic digestion is provided in Anaerobic Digestion Effluents and Processes (Mitchell et al. 2015). Additional information about anaerobic digestion systems is provided in The Dairy Manure Biorefinery (Kennedy et al., forthcoming).*

## Why Complete a Feasibility Study?

A feasibility study incorporates research, data collection, and analysis that effectively evaluates investments in new technology or projects. It answers key questions about a project's technical and financial viability, including project structure and organization and the costs, benefits, and risks involved.

A good feasibility study requires proponents to look at the overall big picture, as well as the many different details involved in creating a successful project. As part of a more formalized decision-making process, the feasibility study works to identify and mitigate risks, and addresses any potential deal breaker or fatal flaw. It also documents the data and analysis, which can help tremendously when the project developer looks for grants or other investment.

The analyses completed are so important that many grant programs require that applicants complete feasibility studies before making project grant awards. Financial investors and banks commonly require more rigorous (“investment grade”) feasibility studies prior to making any investment.

## What are the Different Types of Feasibility Studies?

Different types of feasibility studies can support decision-making at several levels, from general to more specific, although the more specific and in-depth, the greater the time and cost investment.

## Level 1 — General Assessment Study

At their most basic level, a general assessment feasibility study can screen the viability of different opportunities within a broadly defined industry or geographic area. Such an assessment might look broadly at the organic waste byproducts available for co-digestion in a city, county, or region, or within a certain hauling distance of a particular location. Such a study might look at an identified environmental concern or problem and ask if anaerobic digestion could have a role in solving the problem. Such a study might include a social or economic development component, with meetings of potential stakeholders to assess their interest in participating in some kind of anaerobic digestion project.

A general assessment study can also determine whether a specific potential project meets basic criteria or thresholds to support more in-depth analysis. For example, Colorado State University suggests that a particular operation meet at least [two of five indicators for anaerobic digester projects](#) before a more detailed feasibility analysis is merited (Sharvelle 2012). The indicators are as follows:

- Operation meets the definition of a Confined Animal Feeding Operation (CAFO).
- There is potential for “co-digestion”. That is, the livestock waste stream could be combined with the waste stream (generally high-energy organics) of another operation or business.
- Operation receives frequent and credible complaints about odor.
- Operation produces swine or chickens.
- Operation incurs more than \$5,000 in average energy expenditures per month.

## Level 2 — Project-Based, Techno-Economic Study

Incorporating more extensive research and analysis, a techno-economic feasibility study is used to investigate the viability of a potential opportunity. Such a study considers the costs, benefits, and risks of establishing a particular type of project. Typically, a spreadsheet or other tool for calculating and comparing inputs/outputs and costs/benefits will be used. Existing financial modeling tools, specific to anaerobic digestion, can be also be used. These tools are discussed later in this publication.

A techno-economic study will incorporate readily available data about technology options and make adjustments that reflect assumptions about how it would perform under these project conditions. A techno-economic study will have data about the project inputs and outputs and include basic mass, energy, and water balance calculations.

This level of analysis forces project advocates to put their ideas and assumptions on paper and test whether the project has the potential to be sound and realistic. Key outputs from the project-based study are spreadsheets that comprise a financial *Pro Forma*, and likely include sheets on revenues and expenses, an amortization schedule, and project cash flows and returns (Brockhouse 2010).

These types of studies often include sensitivity analyses to explore how changes to one or more key assumptions impact project viability. For example, changes to the cost of fuel or labor, or changes to the revenue received for various end products may have important impacts to a project’s viability. Sensitivity analyses can clarify which of the many assumptions made about a project are most critical to project success.

## Level 3 — Investment-Grade Study

The most rigorous feasibility study is used to validate the marketability of a specific project from an investment perspective. It looks beyond basic techno-economic viability to include site layout designs and detailed equipment specifications. It establishes the actual planned inputs and outputs of a project versus those that are estimated in the techno-economic study. It will also confirm the mass, energy, and water balance calculations. It will identify key providers of feedstocks as well as potential end users, including specific contract arrangements for the feedstocks and product off-takes. Detailed scheduling for construction and obtaining permits along with the impacts on costs may be required to complete this higher level *Pro Forma* financial analysis accurately.

Investment-grade studies often include third-party review as part of the process. During review, investors will ask a well-established consulting engineer to validate the assumptions, calculations, and conclusions of the study.

# What are Key Elements of a Successful Feasibility Study for an Anaerobic Digester System?

## What to Include

Whoever prepares the feasibility study needs to work with clients and stakeholders to prepare the scope of the study. The outline of the feasibility study needs to cover all the important elements of a project. In management literature, various acronyms have been suggested to guide the outline of feasibility studies. For example, in his book *Accounting Information Systems*, James Hall developed the idea of **TELOS**, which stands for Technical, Economic, Legal, Operation, Scheduling (Hall 2007).

Additional or substitute sections may be desired for particular anaerobic digester studies. For example, the concept of “sustainability” may play an important role in the development of an anaerobic digester project. It might be valuable therefore to incorporate the three basic pillars of sustainability—economic, environmental, and social/cultural criteria—as important sections of the study outline.

To be assured that an investment-grade feasibility study is complete, consider what will be required by specific grant or investment targets. In the case of digesters, project developers may seek grants or loan guarantees from the USDA’s Rural Energy for America Program (REAP). This program requires a completed feasibility study for any project with a value greater than \$200,000. The study must be completed by a qualified consultant and include technical evaluation and economic analysis. According to recent program information, a complete REAP feasibility study should include the following sections (USDA 2015):

- Executive summary.
- Economic feasibility, including economic factors that impact the project, such as availability of trained labor, valuable or necessary infrastructure, and general economic conditions in the area of the project.
- Market feasibility, specifically the ability of the project to sell their projected output for a desired price. Include the marketing team and plans, size and scale of the market area, and any existing commitments from buyers or brokers.
- Technical feasibility, including discussions about the technology or system being proposed, the project site, and any environmental impacts. Identify capital and operating costs of the project showing the assumptions and verifiable data used.

- Financial feasibility, showing the short- and long-term financial outlook for the project. Include the projected revenues as annual cash flows and calculate return on investment and net present value of investments. Describe sources of equity, debt and any grant funds or incentives required for the project’s success.
- Management feasibility, describing the management team and their ability to build and manage the project.
- Recommendations, explaining the recommended development.
- Qualifications, describing the qualifications of the people and/or company that completed the feasibility analysis.

As the general outline takes shape, specific subsections or details of the feasibility study for an anaerobic digestion system will likely include some, or all, of the following items:

- Project goals and scope
- Criteria for success
- Inputs: potential feedstocks
- Outputs: the products produced, relative to the inputs used
- Costs: capital expenses (CAPEX) and operating and maintenance expenses (OPEX)
- Revenues and savings
- Financial analyses: cash flow, payback period, EBITDA (earnings before interest, taxes, depreciation, and amortization), net present value, and return on investment
- Sensitivity analyses
- Life-cycle analyses
- Project finance: grants and loan guarantees, debt, and equity
- Project ownership and liabilities: including those responsible to design, build, own, operate, and maintain the project

The purpose of developing a complete outline is to make sure all the right questions are being asked. Here are some of the common technical, economic, and legal questions answered by feasibility studies:

- How much will the project cost to build and then to operate and maintain?
- How long will it take to complete the project and reach a steady state of production?

- How quickly can the project recover its investment costs?
- What is the project's cash flow and financial return on investment?
- What factors are most critical to the project's success?
- What environmental and permitting issues will impact the project?
- What, if any, patent, intellectual property, or licensing issues are involved?
- What insurance requirements, taxes, grants, or incentives may be involved?

## MODEL CALCULATIONS

"Garbage In-Garbage Out" Paradigm

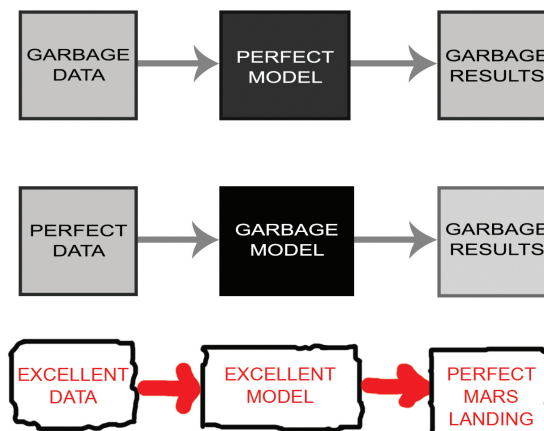


Figure 1. The GIGO Paradigm. Image courtesy of Len Bahr, Ph.D

## Measuring Success

Developers know many different ways for measuring success. It may be profitability, positive cash flow, or a desired level of return on investment. It may also be the cost of treatment per unit of waste, or the price that can be charged to others for treating their waste. Another measure may be the level of subsidy required to make a particular project viable.

There may also be indirect measures of success. If a dairy producer is faced with opposition because of odor complaints, success may be achieved indirectly, through the reduction of complaints about odors. In that case the desired benefit of the investment may be felt immediately, as soon as the digester is operating and reducing the offensive odors.

## Data and Models

Another vital part of the challenge is getting the analyses done right. As discussed above, a feasibility study, especially those done for a specific project, generally involves creation of a spreadsheet-based financial model or *Pro Forma* analysis of the revenues and expenses. Such a model or *Pro Forma* is only as good as its organization, formulas, and the assumptions and data used.

At this point it is helpful to remember the now old adage developed in the early days of computing— “Garbage In = Garbage Out” (Figure 1). The conclusions of any study are only as good as the inputs. If the model formulas are correct, but the data are garbage, you still get garbage. Similarly, if the data are accurate, but the model is ill-structured, the results will not be reliable. It is important to get both the data and the model done right. Only when the data and the model are done well together do you get reliable results.

### Data

Inputs for a feasibility study will come from a wide variety of sources, and may include assumed, theoretical, and measured data. Inputs could also be from a guesstimate (less recommended). Inputs might be borrowed from existing projects or from historical examples, though for some inputs the more recent the data the better. Inputs might be calculated or extrapolated. In rare cases, a feasibility study will use actual data from lab testing or pilot project tests. Unless there is good reason to believe that a specific input is highly reliable, confidence can be improved by using multiple sources of borrowed or historical data for a single input. Having multiple sources will help identify and eliminate outlier data and get closer to a justifiable average. Discussing these questions about sources with clients, partners, or investors is also recommended.

Feasibility studies that include multiple feedstocks or other value-adding technologies in addition to the core anaerobic digester will need input data relating to each aspect of the operation. For example, many projects consider co-digesting high energy organic wastes along with manure. Co-digestion can enhance project profitability, primarily through tipping fees for accepting waste, but also to increased methane output (Astill and Shumway 2016).

Despite this general truth, a feasibility study should carefully analyze whether co-digestion makes sense for a given digester. The assumptions made about the quantity and composition of feedstocks available, cost of acquisition, and the sensitivity of competing markets for those feedstocks can greatly impact overall project viability.

Several features of feedstocks and feedstock markets make it challenging to make defensible assumptions about co-digestion. Public data on feedstocks are usually only available across a broad geographic area (e.g., county or state), making it difficult to figure out what quantities of co-digestion materials are available in more geographically constrained locations. In that case, one may have to carry out on-the-ground surveys or inventories of actual materials. Localized markets can also make it challenging to figure out whether a tipping fee can be charged for accepting materials, or whether materials will have a cost associated with them.

Meanwhile, depending on the specific feedstock being considered, the potential for “hidden” costs also needs to be evaluated closely. The costs for piping or hauling waste materials may be significant in some cases. Costs to store, prepare, or condition materials prior to use in the digester can also be important. Additional considerations for co-digestion operations are covered in more detail in *Considerations for Building, Operating, and Maintaining Anaerobic Co-Digestion Facilities on Dairies* (Kennedy et al., in press) and *On-Farm Co-Digestion of Dairy Manure with High-Energy Organics* (Kennedy et al. 2015).

### Models

It is also important to ensure that the financial model used is reliable. Starting with an established, readily available model is one way to get a project-based, techno-economic feasibility study under way. The [Anaerobic Digester \(AD\) System Enterprise Budget Calculator](#) (Astill and Shumway 2016), developed in the Pacific Northwest and intended for dairy AD, will calculate the net present value of investment in an AD system.

The calculator tool allows for the exploration of a number of different technology options specific to AD, either alone or in combination. Possible choices include manure-only or co-digestion of outside feedstocks, production of electricity or fuel, and a variety of different end uses for solid and liquid digester effluents.

The tool relies on a large number of default data drawn from operating digesters in the Pacific Northwest. Where a user knows that their experience would be significantly different than default data, these values should be replaced. Users can also explore detailed data on revenues and costs over time to better understand the values driving overall project results.

## Other Financial Tools that May Provide Insights for AD System Feasibility Studies

Beyond the anaerobic digester system enterprise budget calculator, a number of other existing models may provide useful insights to those developing AD system projects (Astill and Shumway 2016). These include:

- The Co-Digestion Economic Analysis Tool (Co-EAT). The Co-EAT tool, available from EPA Region 9, provides an assessment of the benefits and costs of adding food scrap residuals to existing waste water treatment digesters. While this analysis tool is targeted to support decision making at municipal AD facilities, the prospective or current dairy AD operator interested in co-digestion could benefit by examining how the food waste is characterized and the assumptions make for transportation and processing of the feedstock.
- The REL-Cost Financial Model. REL-Cost Financial Model, developed by Washington State University Energy Program and used extensively by the NW CHP Technical Assistance Partnership, is a comprehensive analysis tool designed to evaluate the financial feasibility of a wide range of industrial and agricultural energy projects. While this analysis tool is targeted toward combined heat and power facilities, the prospective or current dairy AD operator could benefit by examining the detailed breakout of financial information that includes capital expenditures, sales and savings, operating and maintenance costs, taxes and fees, tax credits, and depreciation, among others.

- Other regional analysis tools.

A number of additional regional analysis tools have been developed to assess both economic and performance parameters of dairy AD facilities. While these tools are focused on the financial/tax structures, operating parameters, and feedstocks in their own regions, they provide additional examples for the prospective or current dairy AD operator to customize a model that best fits their needs. These are:

- [An economic evaluation tool for farm-based anaerobic digesters](#), available from University of Guelph, Ontario Canada.
- [Spreadsheet to Calculate the Economic Feasibility of Anaerobic Manure Digesters on Florida Dairy Farms](#), available from University of Florida IFAS Extension.

Whether working with an existing financial model or building your own, these suggestions may be helpful:

- Show your work; allow readers to see how you made calculations
- Keep assumptions separate from formulas
- Use tools for detecting errors
- Protect key elements of the model by restricting some user access
- Incorporate charts and graphs
- Build in sensitivity analyses

## Revenues

In a feasibility study, project outputs are translated into revenues—either in the form of avoided or offset costs (compared to a baseline with no project), or in the form of income from products sold. Short of having an actual off-take agreement as part of an investment-grade analysis, the value will likely be calculated from data developed from public pricing information, historical data, or data from similar projects. For anaerobic digestion projects, several cautions are appropriate to valuing revenues.

First, investors and partners may value avoided costs or offsets differently than income, and this should be discussed as part of the feasibility study. Avoided costs may include the following:

- Rainwater diversion that reduces pumping or other costs
- Reduction in manure handling and spreading costs
- Odor reduction
- Avoided disposal costs
- Bedding offsets
- Irrigation cost reduction
- Fertilizer cost reduction

Second, feasibility studies should also carefully distinguish between revenues that have already been reliably demonstrated in the U.S. and those that are still developing. Reliable revenue streams, which have been included in many of the hundreds of existing livestock-based digester projects in the U.S. include:

- Methane energy: electric power or fuel—biogas is primarily composed of methane (just like natural gas), which can be used to generate thermal energy, electric power, or as transportation fuel
- Surplus energy: recovered thermal energy—when biogas is used in engines to produce electricity, the engines generate significant amounts of excess heat that can be captured and used for additional value
- Tipping fees for outside feedstock materials accepted for processing
- Value of digester solids: used as animal bedding or processed into compost or other value-added products
- Value of digester effluent liquids: after separation from the solids the liquid effluent still has valuable nutrient value and can be used for crop irrigation and fertilization
- Environmental attributes: renewable energy or fuel credits and carbon credits

Developing revenue streams, on the other hand, have been discussed in research studies, and may be in the initial stages of commercial demonstration, but have not yet been widely adopted. These streams may be more difficult to value, especially where markets are still developing. Developing revenue streams include:

- Recovered nutrients as marketable fertilizers: using a variety of technical approaches it is possible to extract nutrients such as nitrogen and phosphorus from digester effluent
- Ecosystem services: new forms of environmental credits such as water quality or water quantity benefits

- Carbon dioxide: if separated and captured from the biogas, carbon dioxide can support greenhouse gas production and other services
- Bioplastics: a whole new area of research and development that holds promise for the future

Third, evaluating the potential for volatility in revenues is particularly important for anaerobic digestion projects. Consider the volatility of oil and gas prices. The price of natural gas dropped dramatically in the years following 2007 as a result of new hydraulic fracturing (fracking) methods for extracting natural gas. More recently, the price of oil dropped by nearly half over the course of several months in 2015. This kind of volatility makes it very difficult to project revenues over the course of 10 to 20 years—the lifetime of a digester project. It is dangerous to base a 10- to 20-year project on a snapshot of data, but it can be equally challenging to create a defensible set of assumptions for predicting the cost or revenue implications of fossil fuel prices over a long, future time frame.

Similarly, the value of environmental attributes, such as renewable energy credits (RECs), renewable identification numbers (RINs), carbon offset credits, or water trading credits can cause heartburn for project developers and investors. Revenues based on markets or credits that result from the actions of legislatures or the Congress are subject to change, so putting a value on environmental attributes, while based on historical data, must also consider the possibility that something may have zero future value or significantly higher value in the future. These are subjects of discussion with clients and partners.

Sensitivity analysis is one important strategy for coping with uncertainty. These analyses show how changes in costs or valuations within an analysis may affect cash flow or profitability.

## Conclusion

When developing your feasibility model and populating it with all the data points found and developed, **beware of confirmation bias**. Confirmation bias is the process of coming up with a hypothesis or a desired outcome and then working to prove it right, instead of working to prove it wrong. Francis Bacon, the great early scientist, once remarked, “The human understanding when it has once adopted an opinion (either as being the received opinion or as being agreeable to itself) draws all things else to support and agree with it.” The team preparing the feasibility analysis seeks evidence that makes the project less likely to succeed, finds the fatal flaws, and identifies the important risks.

Ultimately, don’t be afraid to “fail.” The important job of the feasibility analysis is to fairly evaluate the potential obstacles and quantify the risks. If the risks are manageable, everyone is better off knowing them in advance. If the risks cannot be managed, you will be the hero for finding them out and saving everyone a lot of time, money, heartache, and grief.

*“Although [an unsuccessful feasibility study] may appear to be a failure, it’s not. The real failure would have been if you had invested your own and others’ money and then lost it due to barriers you failed to research in advance.” David E. Gumpert*

## Acknowledgements

This research was supported by Biomass Research Funds from the WSU Agricultural Research Center; by the Washington State Department of Commerce, and by the United States Department of Agriculture National Institute of Food and Agriculture through award #2012-6800219814.

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