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Oregon Dairy Digester Feasibility Study Summary Report

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Executive Summary

In 2008, Northwest Dairy Association identified a need to promote the development of anaerobic digestion throughout its member producer network. EC Oregon, an independent consultant specializing in the planning and development of biogas plants, was contracted to perform a series of feasibility studies. Anaerobic digestion is receiving increased attention in the United States thanks to interest in renewable energy generation and greenhouse gas reduction. In order to capitalize on this opportunity, it is prudent that the dairy and biogas industries ensure successful installations in the near term. Feasibility studies are necessary to optimize planning, design, construction and operations to mitigate the risk of installations performing below their potential.

EC Oregon requested information and budgetary cost estimates from digestion system designers based in Europe and the United States. Technical challenges are not the primary hurdle to successful implementation of anaerobic digestion at dairies. Technical feasibility of anaerobic digestion is not a significant issue provided a project is planned, designed, constructed and commissioned/operated properly. Anaerobic digestion of dairy manure is a proven technology with a long history, immediately available for commercial applications from a number of qualified vendors.

In order to determine financial viability, EC Oregon produced a 20 year pro-forma for each individual study. The modeling effort indicated that digester systems based on manure only – though technically sound – do not produce attractive financial returns. Financial performance was more sensitive to increases in operational expense or decreases in revenue than capital expense. Boosting methane production via co-digestion of high energy density organic waste is required for project viability. Since revenue is overwhelmingly driven by energy sales, and capital expenditures are essentially subsidized by incentive structures, the incremental cost of construction to accommodate co-digestion feedstock is a prudent investment.

Dairy-based biogas projects deemed financially feasible will require a high level of management during the development process – particularly to secure financing and obtain government incentives. Effective management of the intermittent and uncertain nature of government grant, loan and tax incentive programs is essential to maintaining project cash flow and minimizing interim financing. Effective negotiation of collateral requirements with conventional lenders will also be required to minimize over collateralization.

Maximizing use of local construction knowledge and improving lender confidence in the technology are critical next steps. State permitting laws and local land use regulations need to reflect the substantial benefits of anaerobic digestion. The market for value-added digester co-products requires development. Realizing attractive power purchase agreements, either through negotiation with utilities or state mandate (e.g., feed-in tariff) is crucial.

The collective effort of individual dairies, cooperatives, technology providers, consultants and developers will be required to influence legislators, government agencies, utilities and lenders of the significant financial and ecological benefits this technology can bring to Oregon. If successful, Oregon can set a precedent for other states to follow. Recommendations are provided to facilitate conversation and collaboration between the biogas and dairy industries, regulatory and legislative interests and other stakeholders.

1. Introduction

1.1 PROJECT HISTORY

Anaerobic digestion is receiving increased attention in the United States thanks to interest in renewable energy generation and greenhouse gas reduction. For example, at the United Nations Climate Change Conference in Copenhagen in December 2009, Secretary of Agriculture Tom Vilsack announced new USDA initiatives to promote agriculture-based biogas energy development. The USDA recently signed a memorandum of understanding with dairy producers (via the Innovation Center for U.S. Dairy) to accelerate the adoption of dairy-based biogas installations with a goal of 25 percent reduction in greenhouse gas emissions from manure by the year 2020.

In 2008, Northwest Dairy Association (NDA) identified a need to promote the development of anaerobic digestion throughout its 600+ member producer network. EC Oregon, an independent consultant specializing in the planning and development of biogas plants, was contracted to perform a series of feasibility studies. EC Oregon completed six independent studies to assess the technical and financial viability of on-farm digesters in Oregon. Each study included analysis of dairy manure degradability, compatibility of dairy practices, relevant literature review, identification of locally available co-digestion feedstocks, technology recommendations, energy/co-product output and system cost estimates and pro forma financial analysis. This report summarizes the findings of the individual feasibility studies and draws conclusions regarding the potential for broad scale dairy digester deployment. It is not intended to be comprehensive in all aspects of biogas feasibility and development. Detailed discussions of digester types, ownership models, incentive usage, permitting requirements and interconnection, for example, can be found elsewhere in the literature.

1.2 ANAEROBIC DIGESTION BACKGROUND

Anaerobic digestion is the controlled microbial decomposition of the volatile solid fraction of organic matter in the absence of oxygen to produce biogas, primarily methane and carbon dioxide. This bio-methane in biogas is a renewable natural gas replacement. Various agricultural biomass feedstock can be combined to optimize energy production and financial returns, a practice known as co-digestion. When anaerobic digestion is combined with energy recovery, such as in a combined heat and power unit (CHP), the facility is referred to as a biogas plant. When biogas is utilized in a CHP, electricity can be sold to regional utility companies and thermal energy can be used to maintain optimal digestion temperatures and produce stream and hot water for ancillary processes. Effluent from the biogas plant can be separated into a solid fiber fraction and a liquid fertilizer product. This technology can be instrumental in providing renewable energy while closing the loop on the nutrient cycle.

Biogas plants have been operational throughout Europe for many decades, but are underrepresented in the United States primarily due to historically low energy costs. Domestically, digesters have been used in municipal and industrial wastewater applications as a waste management method. Energy generation was typically not the primary motivation. The waste management mindset has somewhat persisted in the application of manure digesters, but is shifting to a renewable energy focus.

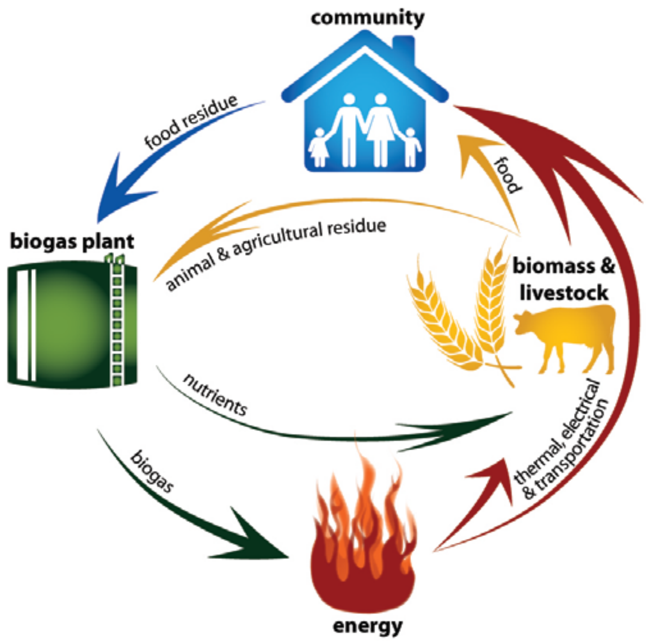

Figure 1 Closing the Loop with a Biogas Plant (EC Oregon, 2009)

Dairy farms present an ideal application for deployment of digestion technology. Dairy manure is a consistent, reliable supply of feedstock that provides chemical buffering capacity and replenishes bacteria required by the digestion process. In return, a biogas plant can provide the dairy diversified revenue or avoided costs, quality bedding, odor control, nutrient management flexibility and reduction of greenhouse gas emissions. The environmental stewardship benefits, while difficult to value monetarily, will be increasingly important to the industry from both the agricultural and food production perspectives.

1.3 FEASIBILITY STUDY RATIONALE

A feasibility study is a typical prerequisite for involvement by lending institutions and some federal and state incentive programs. Furthermore, by identifying technology options, logistical challenges, market opportunities/limitations, funding incentives and other factors that influence technical and financial performance, a feasibility study provides the resource owner – dairies, in the case of the NDA studies – the knowledge to proceed with confidence.

Although dairy manure has been used in anaerobic digesters throughout the world, it is by no means standard business practice. Digester systems do not lend themselves to uniform application. The operational parameters of the dairy will determine manure quantity and quality, appropriate conversion technology, biogas production and energy utilization specifics. Other site-dependent characteristics include co-digestion substrate availability, heat recovery options, permitting, utility interconnection scenarios and constructability. Each digester system must be planned, designed, constructed and operated to meet the characteristics of the situation. Elements of the feasibility study are then further refined in the business plan, should the project move to the development stage.

A pattern of underperforming manure digesters extends throughout the USA. Historically, low-tech, inefficient technologies have been constructed primarily as waste management tools; due to the economics of this type of venture, capital expenditures need to be minimized at all cost. Planning, designing, constructing and operating biogas plants with a renewable energy focus requires a different, though complementary, approach and adds further complexity while reaping greater benefit. In order to capitalize on this opportunity, it is prudent that the dairy and biogas industries ensure successful installations in the near term. Feasibility studies are necessary to mitigate the risk of installations performing below their potential.

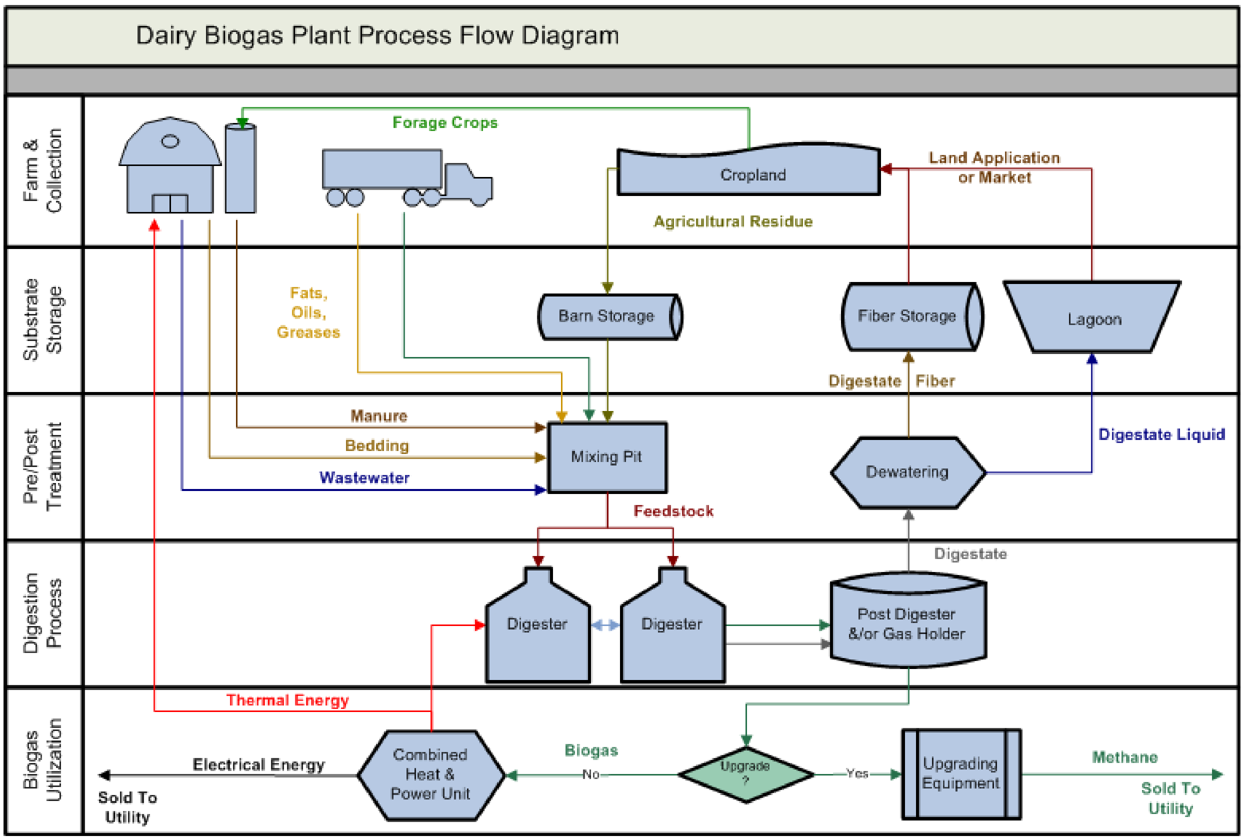

Figure 2. Conceptual Process Flow Diagram for Dairy-based Co-digestion Biogas Plant (EC Oregon, 2009)

2. Synopsis of Dairy Studies

A cross-section of Oregon dairy operations and site-specific variables were assessed for this report. Due to the diversity of farm practices and motivations it is difficult to directly compare the results of any one dairy study with another. Furthermore, some key study elements such as available grants and tax credits, utility power purchase agreement (PPA) rates and refined capital cost estimates were modified at different intervals throughout the studies. Therefore, general ranges and trends from the findings – preferred technologies, feedstock scenarios, energy outputs and financial metrics – are presented in this report. The individual reports will remain confidential.

As expected in any industry wide analysis, no two operations were identical. Each farm represented unique challenges in manure management, interconnection, regional co-digestion feedstocks, land availability, existing infrastructure, nutrient management plans and other variables. In addition to five representative dairies, a "community" digester concept was assessed, in which manure would be transported from surrounding dairies to an offsite destination biogas plant. In all cases, stated dairy motivations for these studies included interest in renewable energy and improved dairy revenue (or reduced costs). For these reasons, this report assumes energy generation and profitability are the driving factors for the development of biogas plants.

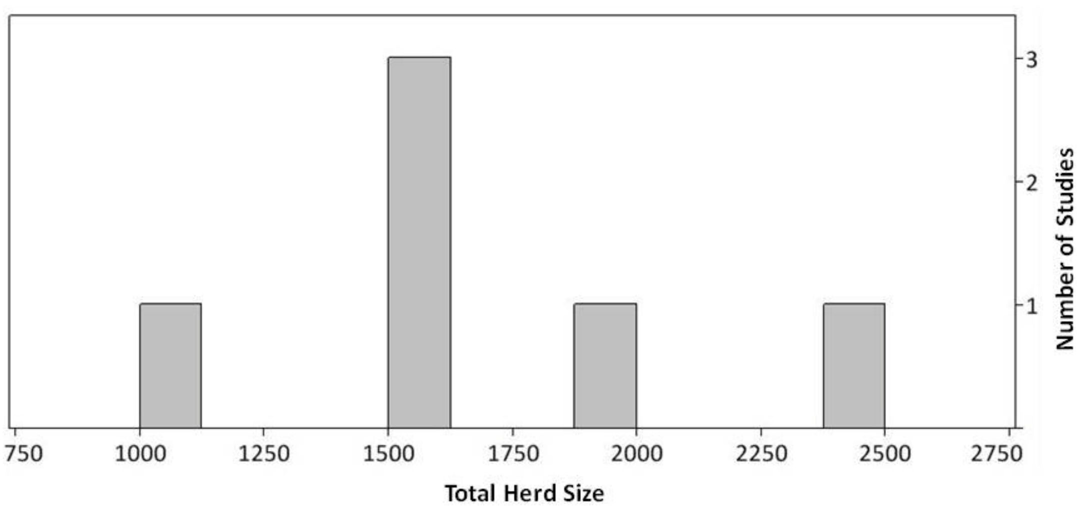

Figure 3 Herd Size Distribution for Participating Studies (EC Oregon, 2009)

2.1 Technical Assessment

Multiple technically viable anaerobic digester solutions are available to Oregon dairies. Several commercially proven digester designs (including complete mix, plug flow and modified upflow sludge blanket) are actively marketed from a multitude of vendors. In an effort to effectively assess the varied technologies, EC Oregon requested information and budgetary cost estimates from 24 digestion system designers, based in Europe and the United States; eight proposals were received that presented a range of technologies and feedstock scenarios.

Standard dairy practices in Oregon are generally compatible with the most common digester designs. In certain cases, concerns arose regarding the type of bedding being used. Wood products (shavings or sawdust) and sand (not common in Oregon) are problematic for all technology types. These bedding types only marginally contribute to methane production and, more importantly, create material/process handling issues. Further, flush manure collection systems present challenges: dilution of the manure stream is incompatible with plug flow digesters; the additional mass of water requires increases in tank size and material handling costs; and thickening of flush water, while technically feasible, results in a loss of volatile solids and hence, energy potential. Scrape manure collection and organic, non-woody bedding types (compost, straw, hulls, etc) are preferred for biogas development.

The type and amount of feedstock is the single largest influence on the design of a digester. It determines the appropriate reactor type and size as well as any required receiving, handling, storage or pretreatment infrastructure. Methane yield of a biogas plant is largely correlated to availability of co-digestion feedstock, not manure production. When a scenario of multiple co-digestion feedstock is compared against manure, the data clearly shows that the manure-only process is not optimized for energy production. Co-digestion substrates can increase the electrical capacity of a proposed system by a magnitude five times or greater than that of dairy manure alone. Stated differently, manure can contribute less than 20% of the methane generated in an efficient co-digestion system. Technically, digestion of dairy manure alone is straightforward; the difficulty is in the economics.

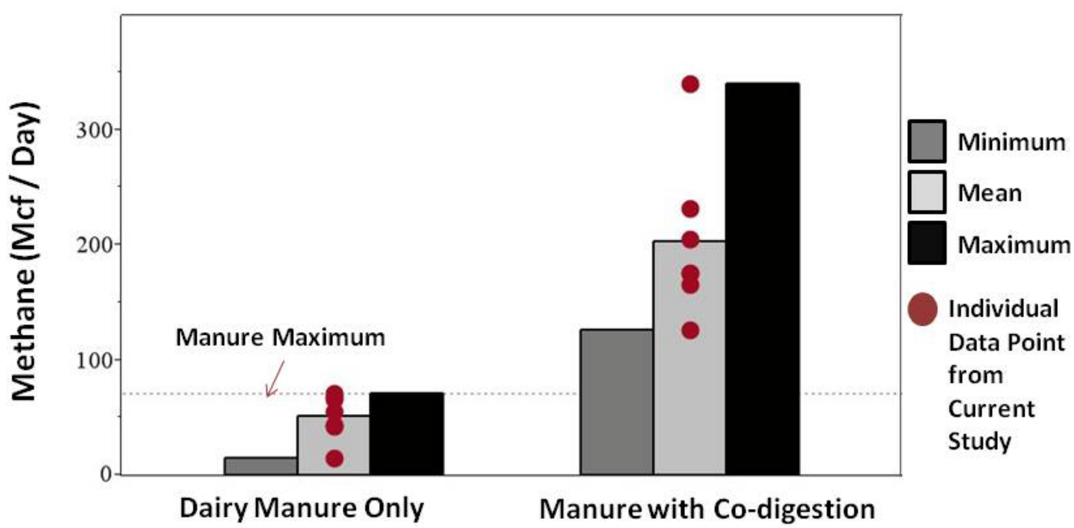

Figure 4 Methane Production Comparison – Manure versus Co-digestion (EC Oregon, 2009)

For dairy participants located in the Willamette Valley of Oregon, similarities in type of co-digestion mixtures persist. Throughout the region, annual ryegrass straw represents the most widely available energy dense co-digestion substrate that is accessible on a consistent basis. Straw, however, is only compatible with complete mix technology and even then, in limited percentages. Other feedstock commonly considered included fats, oils and greases (FOG) and food processor residues, though on a more selective basis. All co-digestion scenarios were modeled with complete mix technology operating at mesophilic (95-100°F) temperatures for reasons of feedstock flexibility and process stability.

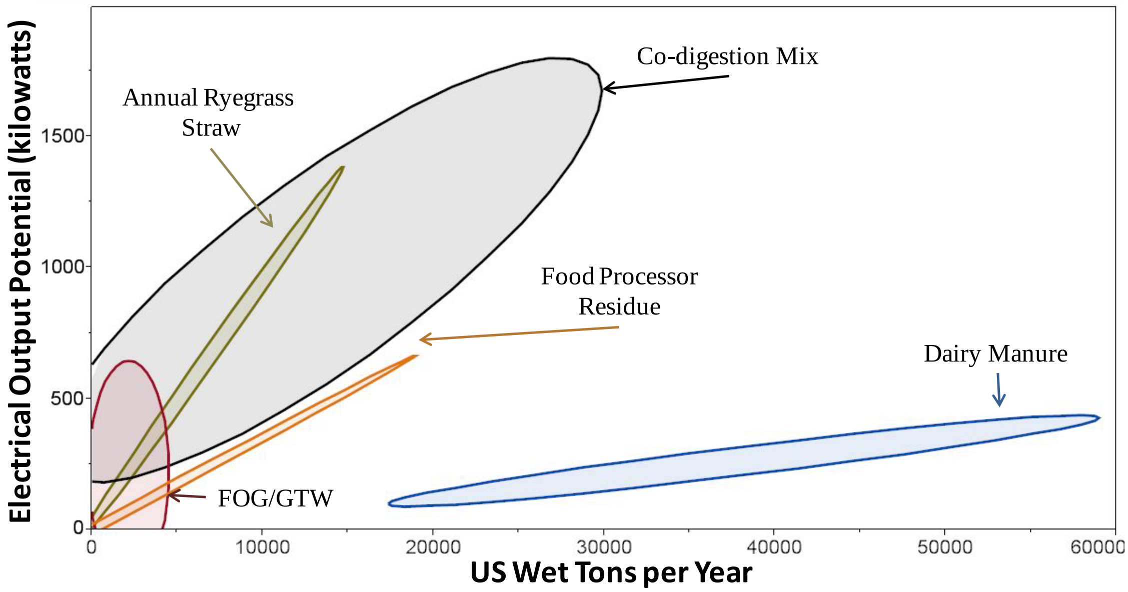

Figure 5 Estimated Electrical Production for Select Feedstock (EC Oregon, 2009)

A regression analysis using only dairy manure as the sole feedstock showed an elongated ellipse with a flat slope; indicating that as the quantity of manure increases, electrical potential does not increase significantly. However, regression analysis of co-digestion blends failed to show a tight correlation, as indicated by the wide ellipse. This is due to differences in energy density of regionally available feedstock. When the co-digestion mixtures were broken into subgroups, correlations were tighter and slopes were rather steep, indicating a large increase in energy as the amount of material increased.

The immediate term use of biogas is as a fuel in a CHP producing electrical energy for sale to regional utilities. This is a proven, scalable approach with multiple vendor options and local service knowledge. When more electricity is generated than the dairy uses on an annual basis, as is the case in these studies, the preferred energy off take is a "sell all" scenario to the utility and thus a "net-metering" scenario is not realistic. Interconnection to the utility, though potentially lengthy and costly, was not a technical barrier in most studies. The estimated electrical output for the co-digestion scenarios in all studies ranged from 600 to nearly 1800 kW. Recovered thermal energy from the CHP would be used to maintain operating temperatures in the digester vessels. Excess thermal energy may be captured for fiber drying or other ancillary uses by the dairy or biogas plant (for example, space heating or adsorption chilling).

It is technically feasible to "scrub" biogas of carbon dioxide, hydrogen sulfide and water vapor into a biomethane product. However, at the present time Northwest Natural, the major natural gas utility in Oregon, has yet to accept upgraded biomethane into their grid. Therefore, upgrading and injecting biomethane is seen as more of a long term possibility rather than a short term reality.

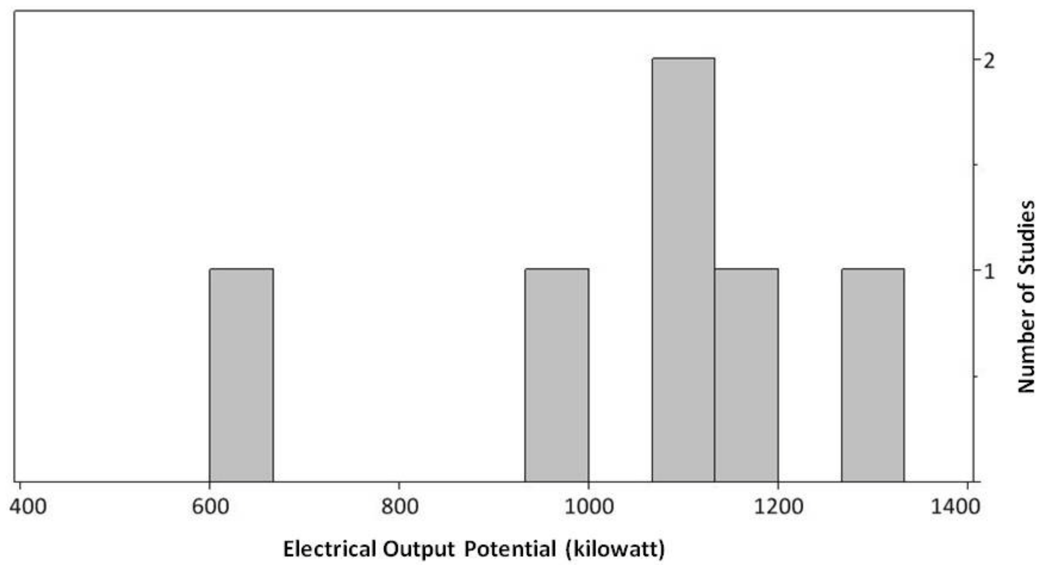

Figure 6 Estimated Electrical Output of Preferred Scenarios (EC Oregon, 2009)

Digester effluent, or digestate, is typically dewatered in a screw press to produce fiber and liquid fractions. A common application for the fibers is as animal bedding. While anaerobic digestion reduces pathogen levels in raw manure by as much as 99%, the fiber should be further sanitized via composting. Alternately, the fiber can be marketed as-is to third party composters, or value added – via a biomass drying process, for example – and sold as nursery planting media. The liquid fraction contains the majority of the nitrogen present in the feedstock and has limited value as dilute fertilizer. Land application on surrounding acres is the most direct method. Nutrient recovery of the liquid fraction, via concentration, would add value by minimizing storage and transportation. However, as with CHP thermal energy utilization, nutrient recovery presents an opportunity for future technical innovations at dairy-based biogas plants. In any case, compliance with the dairy's nutrient management plan is required: offsite feedstock will import nutrients to the dairy while co-product sales would effectively export nutrients off the dairy.

Other seemingly minor technical issues should not be overlooked. In the Willamette Valley of western Oregon, for example, up to 50 inches of rain falls annually. Runoff from silage/compost slabs and alleyways is typically routed through the manure reception pit to the lagoon. This large seasonal spike in water presents an issue for a biogas plant, which requires input of consistent flow and moisture. Therefore, it is critical that rainwater runoff be diverted from manure handling when planning for the development of a biogas plant.

Literature review and digester designer input suggests that appropriate technology is proven and readily available for immediate deployment at dairies throughout Oregon. While, for example, flush manure collection systems, wood-based beddings and co-product value addition present minor but surmountable challenges, dairy practices are compatible with existing digester technology. Quite simply, technical challenges are not the primary hurdle to successful implementation of anaerobic digestion at Oregon dairies. Satisfactory technical solutions have evolved, especially in Europe, to deal with most combinations of feedstock quality and quantity.

Table 1 Technical Considerations (EC Oregon, 2009)

Scenario Variables	Technical Considerations
Manure only	None
Manure with co-digestion	Stable feedstock mixture Material handling and/or storage
Flush manure collection	Lower methane production Thickener and/or larger vessels
Straw feedstocks	Only compatible with complete mix
Wood-based bedding	Not compatible with wet AD technology
Rainwater	Runoff must be diverted
Seasonal feedstocks	Ensiling required

2.2 Financial Assessment

In order to determine financial viability, EC Oregon produced a 20 year pro-forma for each individual study. The model considered revenue streams, incentives, opportunity and avoided costs, capital and operational expenditures, feedstock acquisition and financing costs. Combinations of all dairy practices, technology dependent variables, co-digestion feedstock mixtures and other biogas plant parameters reveals striking differences in financial viability.

Vendor response data fed into the financial model revealed that capital expenditure, energy generation, operations and maintenance (O&M) expenses and feedstock flexibility vary greatly depending on technology type and vendor, all of which significantly impact financial viability.

Figure 7 Variables Influencing Project Viability (EC Oregon, 2009)

The modeling effort indicated that digester systems based on manure only – though technically sound – do not produce attractive financial returns. Manure is a previously digested feedstock (by the cow) and as such has low energy density. Boosting methane production via co-digestion is required for project viability. For example: a covered lagoon scenario operating at psychrophilic (ambient) temperatures will produce a modicum of energy in Western Oregon for a only portion of the year, greatly limiting revenue potential. While this approach is the lowest cost digester solution it will not currently produce attractive returns. Since revenue is overwhelmingly driven by energy sales, and capital expenditures are essentially subsidized by incentive structures, the incremental cost of construction to accommodate co-digestion feedstock is a prudent investment.

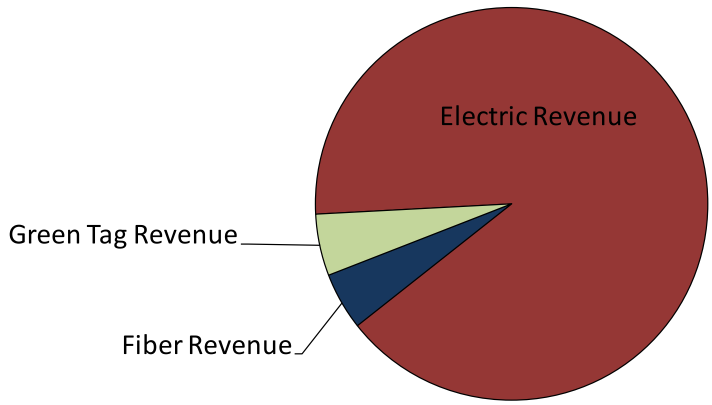

Figure 8 Sample Distribution of Potential Annual Revenues (EC Oregon, 2009)

Due to uncertainty in realizing certain revenue or avoided costs, only electricity, fiber and green tags were deemed realistic revenue streams for the current studies. Some examples of potential unrealized revenue and avoided costs are shown in the following graph.

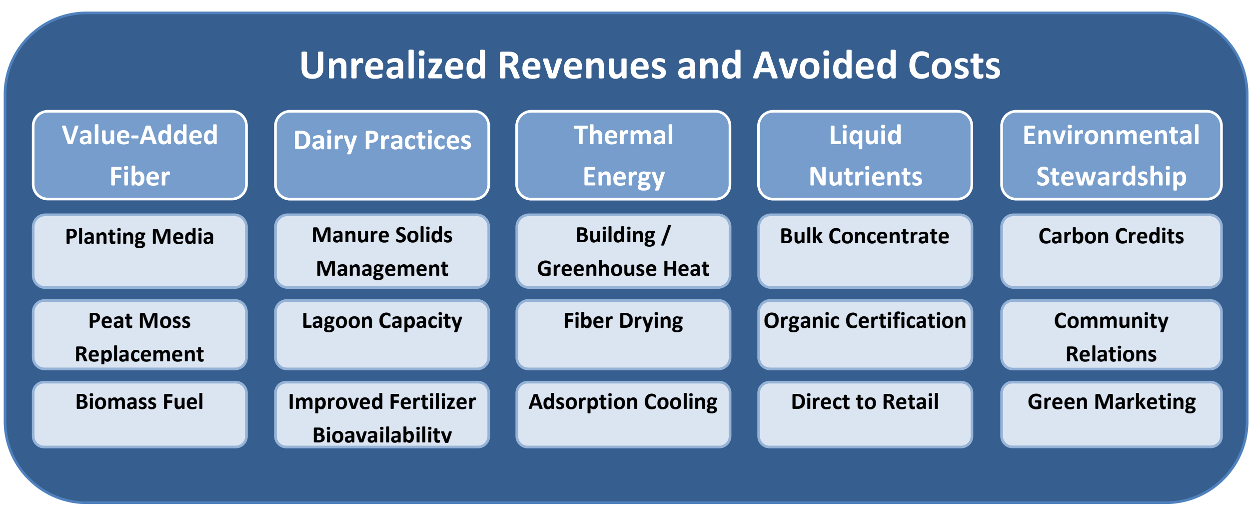

Figure 9 Potential Revenue and Avoided Cost Opportunities (EC Oregon, 2009)

Financial performance was more sensitive to increases in operational expense or decreases in revenue than capital expense. Efficient digester systems with the greatest net energy production financially outperformed those with lower energy yields and/or higher parasitic loads. Since electricity is the primary revenue stream, only when renewable energy sales are appealing can biogas plants be deployed on a large scale. Likewise, as the primary controllable operational expense for a biogas plant, annual feedstock acquisition costs need to be minimized.

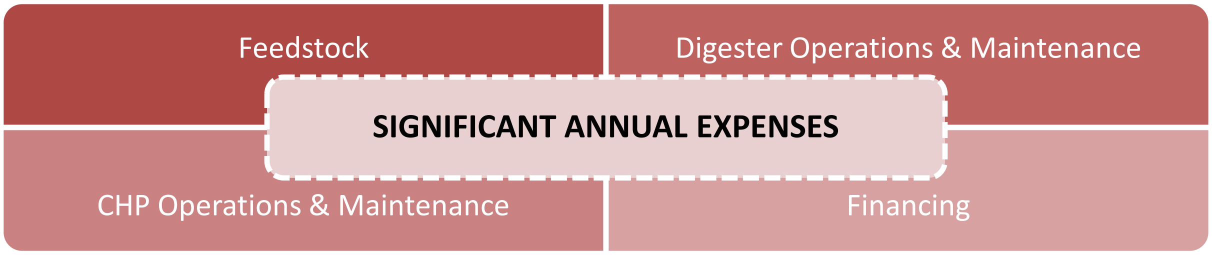

Figure 10 Significant Annual Expenses Impacting Viability (EC Oregon, 2009)

As long as the net feedstock acquisition costs are managed and minimized, co-digest feedstock can boost energy production and result in net financial gain. When certain feedstock can be sourced for free or garner a tipping fee, such as FOG or food processor residue, financial viability further improves. Feedstock mixtures shown to have favorable financial viability for an on-farm biogas plant were not attractive when applied to a destination or "community" biogas plant. The cost of collection, transportation and storage of all feedstock must be carefully assessed.

Most modeled scenarios in this study could absorb the increases in capital expenses required to accommodate co-digestion feedstock. The following pie chart is typical of the distribution of capital expenditures as assumed in the current studies. Equipment and installation costs were provided by designers and vendors, however experienced cost estimators should be employed to properly assess the total installed cost of a project.

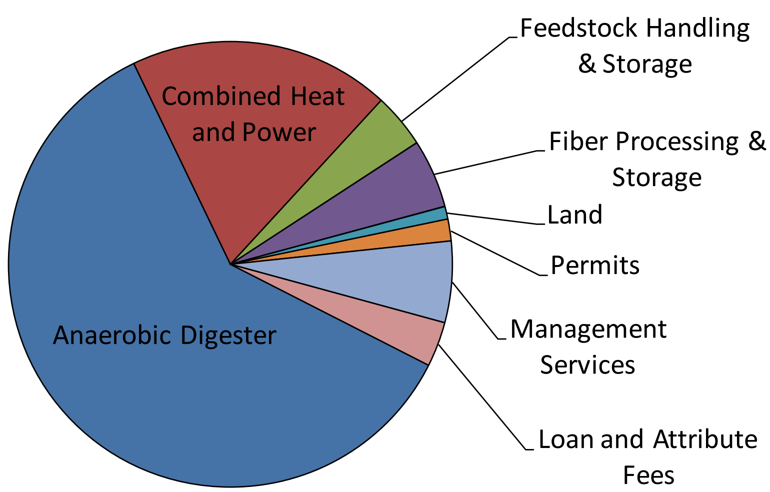

Figure 11 Sample Distribution of Capital Expenditures (EC Oregon, 2009)

The modeling indicates that since dairy manure is not a particularly energy dense feedstock, returns on manure-only digesters are often marginal at best. The ability to accept various co-digestion substrates provides a dairy manure-based biogas plant operational flexibility and improved returns. Just as accepting the low capital cost option does not guarantee a profitable digestion system, co-digestion in and of itself is not a panacea for development. Careful management of all significant variables is required for successful biogas plant development.

Table 2 Financial Ramifications of Biogas Plant Variables (EC Oregon, 2009)

Scenario Variables	Financial Ramifications
Manure only	Limited revenue due to low gas yields
Manure with co-digestion	Improved revenue due to higher gas & fiber production
Flush manure collection	Reduced revenue due to low gas yields or increased CapEx due to increased digester size/thickeners
Avoided cost PPA	Limited revenue from electricity production
Negotiated PPA	Favorable revenue from electricity production
Thermal energy recovery	Opportunity for significant revenue
Value added co-products (fiber & liquid nutrients)	Opportunity for significant revenue
Herd size	Minor impact
Proximity to co-digestion	Control of transportation costs
Transportation of manure	Significant transportation costs (pipeline CapEx or hauling O&M)
Seasonal co-digestion substrates	Additional costs for storage, equipment and O&M
Biogas plant size > 1 MW	Takes advantage of 'Economies of Scale' principle

When an attractive financial return and renewable energy are the primary objectives, complete mix digesters offer the best solution for co-digestion with dairy manure. Although less expensive technologies exist, complete mix technology offers compatibility with co-digestion feedstock and higher net energy generation potential.

3. Risks & Mitigation

Although anaerobic digestion of dairy manure is technically feasible, financial challenges prevent widespread development of dairy-based biogas plants. A determination of financial feasibility does not guarantee a project will be developed – significant effort remains to reduce risk and secure financing. Hurdles are to be expected in any development of this scale and can be mitigated on a case by case basis with proper management and expertise. However, institutional change is required if dairy-based digesters are to contribute substantially to greenhouse gas emission reduction or renewable energy targets in the near term.

3.1 Barriers to Development

The true barrier to widespread U.S. development of biogas plants is apparent in the marginal returns on investment. Power purchase options are less than optimal despite growing interest in renewable energy sources, the nascent status of the industry results in higher capital expenditures and markets for fertilizer co-products have not been adequately developed. Additionally, the currently available major state and federal incentives, while well-intentioned, are primarily tax credit based and/or realized upon commissioning, requiring tax liability and construction bridge funding. Due to unfamiliarity with the technology and current credit/market conditions, lenders likely require that biogas plants be fully collateralized with assets beyond the project.

Oregon is often seen as an ideal location to pursue development of anaerobic digesters due in part to the following:

- Energy Trust of Oregon (a public purpose organization funded by certain Oregon utilities) can provide feasibility funding of up to 50% of the study costs for projects meeting certain criteria.
- Oregon has generous state tax incentives for renewable energy development, including the business energy tax credit (BETC) and the biomass producer/collector credit.
- Oregon has an aggressive renewable portfolio standard (RPS) requiring the largest utilities to source 25% of their sales from renewable sources by 2025.
- Federal incentives also apply, including the producer tax credit (PTC) or investment tax credit (ITC), which is currently available in grant form.

The reality is that Oregon has had no more success than other states in implementing on-farm digester technology at a large scale. The overarching issues preventing widespread deployment of biogas plants are related to financing/funding, incentives and regulations, revenue and capital expenses and ownership challenges. Each barrier listed below increases project costs and/or creates uncertainty and risk, collectively deterring lenders and investors from involvement. Navigating these challenges likely requires professional development teams with the right skill sets and experience.

Table 3 Financing/Funding Issues Preventing Widespread Deployment of Biogas Plants (EC Oregon, 2009)

Financing/Funding
Tax based credits require that sufficient revenue, and subsequent taxes be generated (tax credit appetite) in order to benefit from the credits.
Uncertainty surrounding the "pass through" option; lenders may not consider the BETC as a future source of funds to the project.
Attracting reputable third-party investors can be a costly, lengthy process; may have unreasonable expectations regarding the performance of dairy-based biogas plants.
The ITC grant is not realized until a project is operational, necessitating bridge loans. (This is likewise true of grants and loan guarantees through the USDA's Rural Energy for America Program).
Bridge loans are a potential stopgap measure to provide construction term financing; however, they will incur significant additional expense.
Banks may require biogas plants to be over collateralized, leaving projects unable to qualify for non-recourse financing, unlike other renewable energy projects such as solar and wind.

Table 4 Agency Incentives/Regulations Preventing Widespread Deployment of Biogas Plants (EC Oregon, 2009)

Agency Incentives/Regulations
Lack of coherent local land use/planning rules can result in costly and prohibitive delays.
Any intended leverage from renewable portfolio standard (RPS) goals for promoting biogas energy development is not immediately obvious.
Short time horizons for programs such as the USDA's Biomass Corp Assistance Program (two year maximum window) and Oregon's Biomass Producer/Collector Tax Credit (set to expire in 2012) create financial uncertainty.
Environmental attributes, such as carbon credits, require steep verification fees which are out of scale with the financial profits of smaller projects.
Incentive programs can be onerous and are offered infrequently, with no regard for regional construction windows.
Established rules for importing off-site feedstock to on-farm biogas plants (and that acknowledge the beneficial use) do not yet exist in Oregon, introducing risk from the lender/investor perspective.
Limited sources of feasibility funding exist beyond Energy Trust's ability to provide partial support in the service territory of investor owned utilities.

Table 5 Revenue/Capital Expenditure Issues Preventing Widespread Deployment of Biogas Plants (EC Oregon, 2009)

Revenue / Capital Expenditure
PPAs based on avoided cost schedules are not sufficient to support the investment. Further, they create uncertainty: both investor-owned Oregon utilities recently reduced their avoided cost schedules.
Alternatives to electricity generation, specifically biomethane injection into the natural gas grid, do not currently exist in Oregon.
The sale of environmental attributes based on voluntary markets (green tags and carbon credits) are subject to volatility and speculation; offsets sold on the Chicago Climate Exchange are at an all time low, the existence of these markets in the future is uncertain.
The markets for digestate co-products are not developed, hence are not valued to their full potential and are often not considered verified revenue stream by lenders.
The capital expenditure of a co-digestion biogas plant, with sufficient energy production to generate attractive returns, is such that dairies may not be capable of providing the appropriate equity and collateral required.

Though there are numerous tax credit-based federal and state incentives for renewable energy projects, monetizing these incentives for small to medium sized businesses proves challenging. In most cases tax credit driven attributes do not typically financially empower a dairy. Thus, other sources of funding will likely be necessary to develop biogas plants. Multiple ownership models exist for dairies depending on goals, financial situation and acceptable level of risk. Sole ownership of the biogas plant by the dairy is an option, though financing is more difficult to achieve due to dependency on grants and avoided costs. Such realities have driven many dairies to consider complete or partial third-party ownership.

When investors are brought into the equation there is the expectation that the required equity and collateral can be managed and furthermore, the tax credits can be monetized to support the project. In exchange for taking these risks and addressing these project requirements the return on investment requirements are typically high. Profit sharing, operational responsibilities, default penalties and other terms of a resource agreement between the dairy and the project company need to be carefully assessed.

3.2 Overcoming Barriers

The collective effort of individual dairies, cooperatives, technology providers, consultants and developers will be required to influence legislators, government agencies, utilities and lenders of the environmental and economic value of biogas technologies on our dairy farms. If successful, Oregon can set a precedent for other states to follow. The following table is intended to facilitate conversation and collective bargaining to help further collaboration between the biogas and dairy industries, regulatory and legislative interests and other stakeholders.

Table 6 Recommendations and Benefits (EC Oregon, 2009)

Recommendation	Dairies	Cooperatives	Agencies	Legislature	Retailers	Utilities	Lenders	Consultants	Tech Vendors	Benefit
Promote digesters as part of long-term solution for dairy viability	X	X	X	X	X			X	X	Supports long-term success of biogas energy; facilitates financing, GHG reduction and dairy viability
Spearhead development of markets for all biogas plant products (electrical/thermal energy and fiber/nutrients)		X						X		Supports long-term success of biogas energy; facilitates bank financing, GHG reduction and dairy viability
Provide 'year round' bridge financing against federal/state grants and tax credits to secure construction financing			X	X			X			Ensures immediate deployment of projects and supports rural wealth retention
Provide 'year round' long-term financing against project level collateral			X	X			X			Reduces onerous nature of acquiring loan guarantees and collateral (beyond project); supports rural wealth retention
Fast-track project incentives, permits and interconnection			X			X				Improves project deployment and reduces development risk
Institute feed-in tariffs				X						Supports the long term success of biogas energy; facilitates financing
Purchase biogas energy through wheeling arrangements with utilities					X					Supports long-term success of biogas energy; facilitates financing and GHG reduction
Provide process guarantees and guaranteed maximum prices for turn key projects									X	Supports development of biogas energy and facilitates bank financing
Secure and readily distribute funds for feasibility studies		X	X			X				Facilitates deployment of well planned projects
Engage professional services for feasibility studies	X	X					X		X	Ensures proper planning
Educate stakeholders about the value of biogas energy	X	X	X		X			X	X	Raises overall awareness of the value of biogas energy
Support need for energy dense co-digestion feedstock	X		X		X			X	X	Improves financial returns and GHG reduction
Support use of local construction companies	X						X	X	X	Facilitates local job creation and wealth retention

3.3 Analysis of Potential Solutions

A representative financial sensitivity analysis for a 1300 kW co-digestion biogas plant is provided to illustrate the current state of financial viability, significance of key variables, and benefits of proposed solutions. This analysis draws on variable ranges consistent throughout the studies. Development experience suggests that input assumptions will vary, even at the feasibility stage, until contracts with suppliers/offtakers are in place. As a business plan is developed, confirmation of input assumptions will tighten the corresponding ranges for pre-tax return on investment (ROI). In this model, the federal ITC grant is applied to debt principal upon commissioning. The state BETC is retained (not passed-though), but falls below the line for pre-tax ROI calculations, hence is not valued in this analysis.

Table 7 Select Financial Model Assumptions (EC Oregon, 2009)

Debt : Equity (% Ratio)	**70 : 30**
PTC/ITC option	**ITC Grant**
Loan terms	**10 year, 7.5%, 2 points**
Inflation Rate	**3%**
Business Energy Tax Credit (BETC)	**Retained (below the line)**
Biomass Producer/Collector Tax Credit	**Available to straw, FOG, food processor suppliers**
Depreciation	**MACRS + ARRA-enabled Bonus**
% Fiber to sell	**60% (remainder to bedding)**
Starting Dollar per REC	**$7.75**
Other incentives	**$500k USDA grant**

In order to illustrate the impact of energy sales, a sensitivity analysis with three scenarios is described below. Please note that this analysis is intended to help aid in conceptualizing the intricacies of a biogas plant and is not indicative on any one study. Avoided costs at the farm, carbon credits, thermal energy and additional co-products have not been valued.

***Scenario 1.* - Avoided cost schedule**. Investor owned utilities are required by the Oregon Public Utility Commission to purchase power from Qualified Facilities at a rate equal to their avoided cost of production. This scenario is modeled after one utility's currently approved rate schedule. In 2011, for example, on-peak rate is $0.057 / kWh and off-peak is $0.046 / kWh.

***Scenario 2.* - Negotiated PPA**. Utility companies, public utility districts or electricity cooperatives in and out of Oregon may be willing to purchase "bundled" renewable energy (combined kWh and RECs) at a premium. This scenario assumes a net PPA of $0.09 / kWh, after wheeling costs, can be successfully negotiated. PPA escalates at rate of inflation.

***Scenario 3.* - Feed-in Tariff (FiT).** A FiT requires utilities to purchase renewable energy at above-market rates. A number of European countries, Canadian provinces, and U.S. states and municipalities have implemented or are considering FiTs mechanisms. This scenario assumes an Oregon FiT of $0.12 / kWh is enacted for biogas-generated electricity. PPA escalates at rate of inflation.

The additional parameters to be varied within the model were limited to those found in the following table. Each variable was allowed to independently vary within the aforementioned constraints for 25,000 iterations for each scenario.

Table 8 Variable Ranges for Sensitivity Analysis (EC Oregon, 2009)

Parameter	Range	
Net Feedstock Expense/Revenue ($/ton)	$13.45 revenue	$16.30 expense
Fiber Revenue ($/Ton)	$5	$39
AD O&M	$100,000	$250,000
CHP O&M $/kWh	$0.010	$0.020
Total Biogas Plant Capital Expenditure	$7 Million	$10 Million

This analysis indicates the most significant variable for project viability is the power purchase agreement. Capital expenditures are also signficant. However, capital expenditures are a one time factor that account for less than 10% of a biogas plant's long term viability. After commisioning, management of variables other than captial expenditure determines long term financial viability. A biogas plant can tolerate increases in capital expenditure better than losses of revenue, or increased operational expenses. Optimizing digester efficiency and minimizing costs will further improve returns.

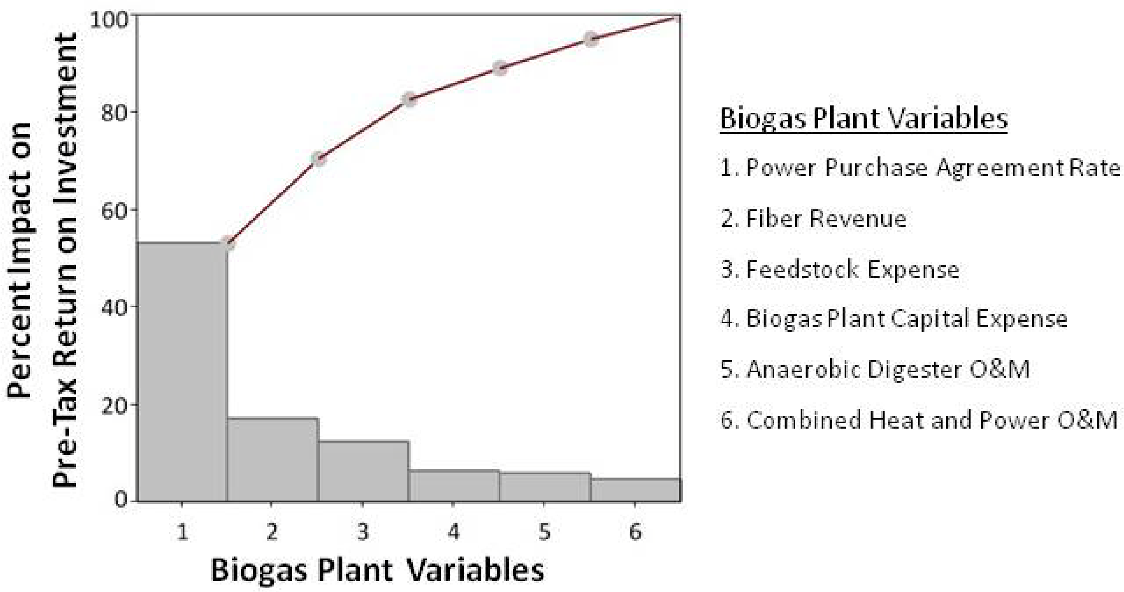

Figure 12 Impact of Biogas Plant Variables (EC Oregon, 2009)

Multiple entities are responsible for controlling and mitigating the impact of these main variables. To some extent biogas plant capital expense, annual anaerobic digester O&M, annual CHP O&M can be controlled via technology choices. In this analysis, other aspects independent of technology providers are more significant. Therefore, all parties interested in promoting dairy-based biogas development should play a role in improving power purchase rates, controlling feedstock acquisition expense, and establishing co-product markets.

As indicated below, there is a shift toward improved returns with each sucessive scenario. The avoided cost schedule (Scenario 1) shows a large percentage of pre-tax ROIs approaching 20 years, and no probability of having an ROI of less than 10 years. Negotiating a bundled PPA at a premium rate (Scenario 2) improves the financial viability considerably with a high probability of a pre-tax ROI less than 15 years. The shift is even more dramatic under the FiT scenario (Scenario 3) indicating projects have a good probability of a pre-tax ROI of less than 10 years. Note that tax credits, depreciation and other “below the line” benefits are not considered in this analysis.

The variability within each scenario illustrates the importance of diligent management during the development process. The large bell curves are derived from the entire range of all key variables. Note the ten year spread on pre-tax ROI, regardless of power purchase scenario. Prudent management of operational expenses (as highlighted by the smaller, shaded areas within each bell curve) tends to result in more favorable returns.

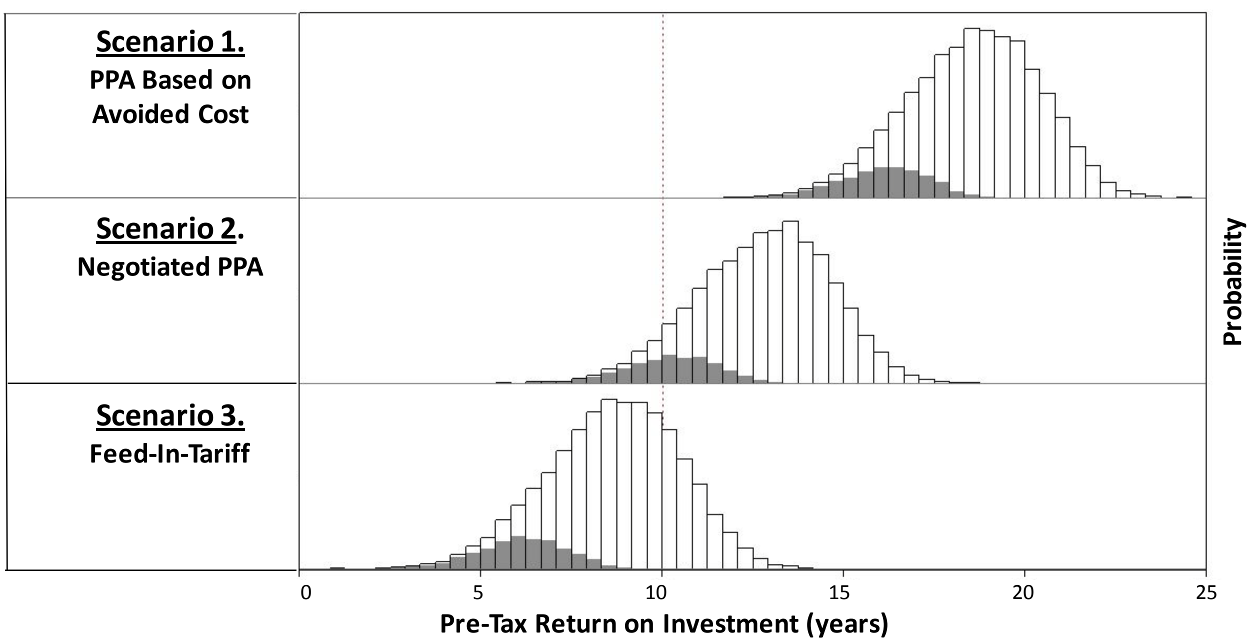

Figure 13 Impact of Power Purchase Rates on Biogas Plant Financial Viability (EC Oregon, 2009)
Histograms of financial metrics for proposed power purchase scenarios are provided. The shaded areas in each histogram are tied to effective management practices. Dotted line on Pre-Tax ROI represents a 10-year return. The charts are intended for conceptualization purposes only. Their outputs cannot and should not be extrapolated to site-specific projects.

Conclusions

The findings of this report were based largely on individual feasibility studies performed by EC Oregon at six Northwest Dairy Association member dairies in Oregon. Additional insights into the challenges of financing a dairy-based biogas project are being gained as development efforts proceed. Lessons learned from these studies and ongoing project development will help identify and mitigate risks for future on-farm development of biogas plants not just in Oregon, but throughout the U.S.

Substantial Environmental and Economic Benefits

Anaerobic digestion can be a financially viable business option for dairies when all factors are considered and managed optimally. The benefits of anaerobic digestion are numerous and well-documented. Biogas plants can generate diversified revenue while reducing greenhouse gas emissions, mitigating odor issues and providing nutrient management flexibility to dairies. This technology has the potential to solve waste handling problems while producing renewable electrical and thermal energy and fertilizer co-products – a win-win for dairies and their communities. State permitting laws and local land use regulations need to reflect this reality.

Proven Technology Exists

The technical feasibility of digestion on dairy farms is not a significant issue provided a project is planned, designed, constructed and commissioned/operated properly. Anaerobic digestion of dairy manure is a proven technology, immediately available for commercial applications from a number of qualified vendors. Technical assessment of digester designs, including front- and back-end solutions, is required to ensure compatibility with project goals. Feasibility studies are crucial to identify project potential and possible risks.

Planning & Management Expertise is Necessary

Since dairy manure is not a particularly energy dense feedstock, and biogas plant revenue is overwhelmingly driven by energy sales, manure-only digesters lack the profitability to attract investment interest. Co-digestion of energy dense feedstock is required for project success; locating appropriate and available sources for co-digestion is an important step in project development. Adding value to co-products and controlling operating expenses are both important to project viability. Navigating

Government Incentives, Lending Practices and Power Purchase Agreements Need Improvement

Government grant and loan guarantee programs are intermittent and not conducive to timely development. Tax-credit driven incentives are difficult to monetize; sunset provisions add further uncertainty. Many incentives are not made available until after plant commissioning, requiring additional financing. Given the current state of the U.S. dairy industry, the level of capital investment required for a biogas plant may necessitate third party investment. Even if equity requirements can be met by other means (i.e., grants) overcollateralization is still required by conventional lenders. Realizing attractive power purchase agreements, either through negotiation with utilities or state mandate (e.g., feed-in tariff) is crucial.

Dairy-based biogas projects deemed financially feasible by all reasonable criteria will likely experience hurdles in the development process – particularly in securing financing. These barriers may – in select cases – be overcome on a project by project basis by development teams with specific experience and regional knowledge. However, to expedite broad scale deployment the obstacles must be removed. A concerted effort by the dairy and biogas industries, working with governmental agencies, legislators, utilities and lenders, is required. Recommendations in this report are intended to facilitate conversation and action. The current climate well suited for substantial progress.

Acknowledgements

Northwest Dairy Association (NDA) identified a need to support the development of anaerobic digestion throughout their producer network. NDA provided support in identifying likely candidates that represent a cross section of their producer network.

Energy Trust of Oregon (ETO) is a public-purpose organization mandated by the Oregon Public Utilities Commission and funded by utility ratepayers that provides financial incentives to help support the development of renewable energy projects in Oregon. ETO provided 50% funding for each study.

Bonneville Environmental Foundation (BEF) is a national, nonprofit organization focused on reducing carbon footprints, renewable energy development and watershed restoration. BEF provided 50% funding for two studies.

Oregon Department of Energy - Community Renewable Energy Feasibility Fund
In October of 2008, EC Oregon applied for the Community Renewable Energy Fund provided by Oregon Department of Energy. In June of 2009, EC Oregon was awarded funding to cover 50% of the final two studies.

Participant Dairies paid 50% of the funding for the first two studies. EC Oregon would like to acknowledge the risk these two farms took at the onset of a challenging period for dairies nationwide in an effort to advance digestion development locally. EC Oregon appreciates the cooperation and support they received from all participating dairies.

Digester Technology Providers
Finally, EC Oregon is appreciative of the cooperation and detailed data that was provided by vendors throughout these studies in order to address each project's individual attributes. This report is not endorsing any particular digester provider.

Statement of Qualifications

EC Oregon is the regional expert in providing objective assessment of biomass-to-energy projects with a recent focus on biogas. Since 2005 EC Oregon has performed multiple private- and public-funded anaerobic digestion feasibility studies. More qualification data can be found at www.ecoregon.com.