Anaerobic Digesters for King County Dairies

Final Report

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King County

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Natural Resources and Parks
Water and Land Resources Division
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I. Executive Summary

Environmental Resource Recovery Group, LLC (EnRRG) entered into a contract with King County DNRP to study the feasibility of "**Anaerobic Digesters for King County Dairies**". Findings of the study are summarized in this document and have been presented to the sponsors, in preliminary fashion, throughout the study period.

> **There is a unique opportunity in King County for public interests, utility companies and livestock producers to work together for their common benefit, in an innovative and high profile manner. By combining anaerobic digestion technology with reverse osmosis membrane technology, manure from dairy cows can be converted to energy, organic fertilizer, pure water and environmental credits. An environmental liability can be converted to multiple assets. Properly designed and operated, a centralized dairy waste conversion project will produce a more secure environment in King County, needed financial and regulatory relief for milk producers of the county and strong financial returns for potential investors.**

The nation is reassessing its commitment for developing renewable energy while, at the same time, protecting the environment. Public policy is being rewritten to accommodate both. King County is working hard to protect its local environment while maintaining jobs and encouraging desirable economic growth. Utilities of the region are being challenged to develop and promote methods and products that are both renewable and environmentally friendly. Dairy producers of King County are looking for ways to survive devastatingly low milk prices and escalating environmental restrictions while they maintain optimism for the future. The objective of this study is to evaluate the use of anaerobic digestion technology in King County to help obtain these goals.

For purposes of this study, feasibility criteria are:

1. **Processes must be technically sound and stable.**
2. **Project must meet the needs of the affected parties.**
3. **Project must demonstrate acceptable financial returns.**

Summary of Findings:

1. A farm scale digester, serving one or a small group of adjacent dairies does not meet the standards for feasibility. Financial returns are low and needs are not well satisfied.
2. A centralized digester to serve dairies of the Enumclaw Plateau does meet feasibility requirements. It can meet the needs of all parties and produce acceptable financial returns. Transformation of waste to economic value is illustrated in the table:

Central Digester Inputs and Outputs – Annual

Digester Inputs		
Cattle Manure with Bedding	252,000	Tons @ 8% DM
Digester Outputs		
Biogas Energy	107,675	Million Btu
Converted to Electric Energy	10,386,000	KWh
Solid Organic Fertilizer	36,568	Tons
Liquid Organic Fertilizer	3,000,000	Gallons
Re-use or Discharge Quality Water	47,000,000	Gallons
Greenhouse Gas Reduction	38,576	MT CO_2e

The project that best meets the tests of feasibility has the following characteristics:

- Waste is collected daily from the participating dairies and trucked to a central digester location. The average hauling distance would be at about 2.5 miles.
- At the digester site, the manure is converted biologically into biogas and a liquid effluent with suspended solids that are essentially odor- and pathogen-free.
- The biogas is converted to electrical power and sold to a utility.
- Digester effluent is separated into a solid component and a liquid component.
- The solid component is further processed and sold as organic fertilizer – bulk or bagged.
- The liquid portion is further processed using membrane technology into a concentrated liquid (also organic) fertilizer and re-use or discharge quality water.
- The liquid fertilizer is applied on the land of participating dairymen or exported from the region for application on other cropland. Alternately, it could be further reduced and blended back into the solid component, eliminating the need for any land application.

The centralized waste conversion project meets the tests for feasibility because:

1. The technologies are proven and stable. Anaerobic digestion is used in many applications around the world. The membrane technology (UFRO) is the same as used in municipal water plants and desalination. Technical advances in the past few years have brought the economics of membrane treatment into a range where it can be used in this application.

2. It serves the needs of the participants:

   a. Dairymen -- Significantly reduces the burden and costs of manure management. Manure is removed on a daily basis from their property and does not return. Liquid nutrients are applied to their land if/as they are needed. All of the mandated nutrient management compliance record keeping can be done at the central site and dairymen are freed to manage their milk production business, including expanding cow numbers if desired.

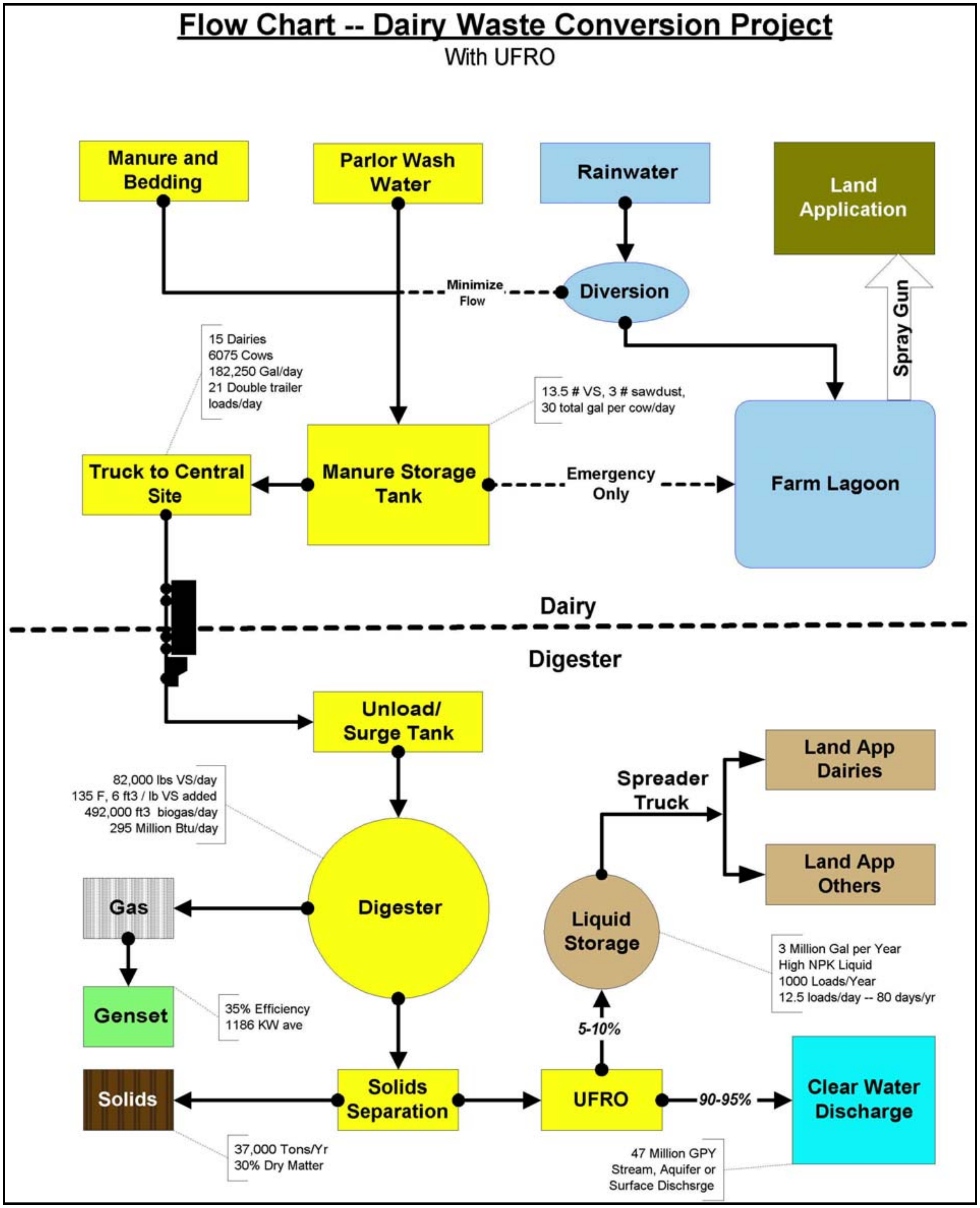
   b. Utilities – Produces both renewable energy and environmental incentives. The electricity is valued as market energy, but the incentives allow the utilities to meet their renewable/environmental goals. Incentives include a carbon credit (greenhouse emissions reduction), a renewable power component (Green Tags) and a Federal Production Tax Credit (if/when the Energy Bill is passed by Congress and signed into law). Values for the utility partners are well defined and predictable.

   c. Public – Potential odor problems and surface water runoff concerns from land application of manure are completely eliminated. Raw manure is converted into a benign, re-use or discharge quality water which can re-enter the watershed without pollution concerns, and solids are converted to a high quality organic fertilizer and soil amendment. The project can stimulate additional economic activities such as 1) blending and bagging of certified organic fertilizer, 2) organic and/or hydroponic vegetable production, 3) mushroom production and 4) other specialized organic/environmental business activities which utilize co-products of the project.

3. The forecast project economics are favorable, and should be sufficient to attract investors.

Total Capital Investment	**$7.59**	**Million**
Annual Net Revenue	**$1.16**	**Million**
Return on Total Investment (IRR)	**13.8**	**%**
Payback @ 5.5% Interest	**8.6**	**Years**

Exhibit 1 -- Diagram for the Dairy Waste Conversion Project



This is a simplified diagram of a centralized anaerobic digester project for the dairymen of King County. Notice the one-way flow of manure from the farm and the return of concentrated liquid nutrients via spreader truck. The UFRO component is an ultrafiltration/reverse osmosis system to remove all suspended and nearly all dissolved solids from the water prior to re-use or discharge, while it concentrates the liquid nutrients into an economically transportable product.

Exhibit 2 – Project Summary – Centralized Dairy Waste Conversion Project

ECONOMIC FEASIBILITY OF BIOGAS RECOVERY AND UTILIZATION

Project Name: **King County Central Digester with UFRO**

Dairy --- Thermophilic 13.84%

Project Summary

This project uses a heated digester at 135 degrees F. It requires a 1482 KW generator. Electricity which is sold is valued at $0.035 per Kwh. In addition, 0% of the recoverable generator heat is utilized at a value of $5 per MMBtu. The project requires $7592078 capital investment and returns $1135988 annually giving a 13.8% return on investment and a payback in 8.6 years at 5.5% interest.

Project Description

State:	Washington	
Climate Zn:		
Enterprise:	Dairy	
Enterprise Units:	6,075	Milkers
Digester Type:	Thermophilic	
Daily VS	82,013	lbs
TS %	8.00%	
Daily Biogas	492	000 Ft3
Daily Methane Ener	295	MMBtu
Ave Elect Prod	1186	KW
Digester Vessel	2,503	000 gal
Fertilizer Sales	36,568	Tons

INVESTMENT ANALYSIS

Capital Costs

Digester	2.50	M gal	
Generator	1482	Kw	
Digester & CoGen			$2,986,033
Fertilizer Plant			$0
Capital to Force			$0
+/- Other Capital Items			$3,081,352
Engineering&Contig			$1,524,693
CHP Credit	No		$0
Total Capital Costs			$7,592,078

Using Worksheet

Returns

			Monthly	Annual
Offset Electric Cost	$0.065	/kwh	$0	$0
Sale of Electricity	$0.035	/kwh	$30,292	363,510
Offset Demand Charge	$2.00	/kw	0	0
Recovered Heat Value			0	0
Gas - On-Site Use	$5.00	/MBtu	0	0
Gas - Sale	$4.00	/MBtu	0	0
+/- Income to Balance			0	0
+/- Other Value			138,151	1,657,807
Total Savings			168,443	2,021,317
GenSet O&M				(103,860)
+/- Adjustments			(65,122)	(781,469)
Net Benefit			$94,666	$1,135,988

Investment Analysis

R.O.I. (Internal Rate of Return)		**13.84%**
Payback Years @	4%	7.93
@	5.5%	8.56
@	8%	9.94
Net Present Value 20 yr	5.5%	$5,983,413

What If ????

	R.O.I.	Payback Yr @ 5.5%
Decrease Capital Costs by 25%????	19.37%	6.02
Increase Net Benefits by 25%????	18.02%	6.50
Both the Above????	24.63%	4.65

This table from the economic simulation model summarizes the "base case" scenario for a centralized project. The "base case" is EnRRG's expectation of the most likely outcome, and is neither the "best" nor the "worst" possible outcome. Throughout this report, sensitivity analyses and critical factor analyses illustrate factors that affect the potential outcome of the project, both negatively and positively. In operating the project, careful attention to obtaining results for the critical factors that equal or exceed base case levels will lead to a successful outcome. The opposite is also true.

Exhibit 3 – Economic Analysis of Dairy Waste Conversion Process

Proforma Investment and Operating Statement

Dairy --- Thermophilic 13.84%

Income

Electricity		
Net metered Power	$0	0%
Demand	$0	0%
Sale to Utility	$363,510	18%
Power Based Incentive		
Production Tax Credit	$186,948	9%
Renewable Attributes	$207,720	10%
Carbon Credits	$154,304	8%
User Fee	$243,000	12%
Nutrient Value		
Residual Solids	$731,352	36%
Liquid Fraction	$134,483	7%
Total Revenues	$2,021,317	100%

Expense

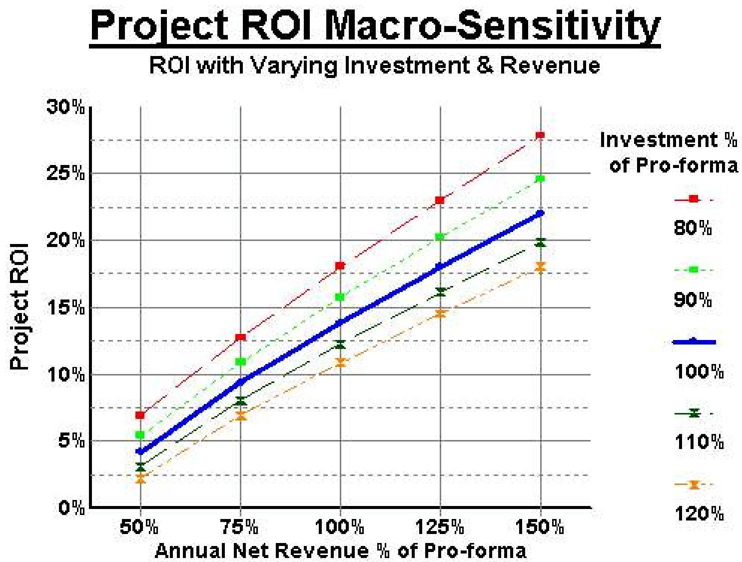
Operations		
Genset R&M	$103,860	12%
Digester Operations	$350,000	40%
Solid Residuals Handling	$182,838	21%
Water Treatment	$63,879	7%
Transportation		
Waste Inbound Hauling	$184,751	21%
Total Expenses	$885,329	100%

Net Revenues

Net Revenues	$1,135,988	56%

Capital

Digester & Equipment	$1,965,102	26%
GenSet & Interconnect	$1,470,931	19%
Solids Handling	$1,231,352	16%
Rolling Stock	$350,000	5%
Land and Development	$500,000	7%
Engineering & Conting.	$1,524,693	20%
Other	$550,000	7%
Total	$7,592,078	100%



The two tables of Exhibit 3 show pro-forma financials for the project and the sensitivity of the project's financial performance through a wide spectrum of deviations from plan, both positive and negative. The project exhibits a strong financial performance that can survive stresses from either income shortfalls or capital expenditure overruns. The Macro-Sensitivity chart shows that, if capital investment meets plan, the project would have nearly 5% ROI even if net revenue was only one-half of expectations. Also, if net revenue is equal to plan and capital investment exceeds plan by 20%, the project would still have an ROI in excess of 10%.

Critical issues for the success of a centralized digester/waste conversion project

There are certain issues that must be recognized before going forward with a digester project:

1. Production Tax Credit (PTC) – The production tax credit for renewable electricity production that is included in the economic analysis (all cases) is not currently in effect for projects such as this one. It is very likely the PTC will be extended and that the Energy Bill of 2003 will extend the PTC to include power produced by all biomass. If the PTC were not applicable to the digester projects evaluated in this study, the value of the environmental credits would be reduced by 1.8 cents per kilowatt-hour, and the return on investment would be reduced accordingly. (See the Critical Factor Analysis tables of Appendix C)

2. Value of Organic Residuals – The sale of solid organic residuals constitutes over one-third of the total revenues of the project. Even though the residuals are priced very conservatively relative to their intrinsic value, without an effective marketing effort the expected value will not be attained. Conversely, since the product is priced at a relatively low value, there is significant upside potential for this income component, with a correspondingly improved project payback.

3. Solids content of Transported Wastes -- It is imperative that rainwater is prevented from mixing with the collected manure at the dairy farms. The economic analysis is based on 8 percent solids, on average, in the transported wastes. If the solids content drops below 4 percent, the economic feasibility of the entire project is threatened. (See Exhibit 18, page 30) If the project is implemented, great effort must be put forth at each individual dairy to minimize the extra water (rainwater and parlor wash water) that mixes with the manure.

4. While the involvement of three dissimilar parties in a mutually beneficial project may be considered positive and innovative, it must be implemented properly in order to achieve the desired results. This concern bears upon the ownership structure for the project, since some potential ownership structures are more prone than others to a conflict among the affected parties.

Next Steps

If the dairy digester/waste conversion project is to be considered for implementation, several key steps must be undertaken. Some of those steps include, not necessarily in sequential order:

1. Ownership Structure and Financing -- Determine who will own the project and the appropriate sources of financing, including all possible grant opportunities. Begin the necessary procedures for financing and grants.

2. Operating Agreements -- Determine the parties who will participate in the project and their respective roles, including the dairymen, utilities and public entities. Begin formalizing the obligations and responsibilities – power purchase agreements, manure collection contracts, carbon credit auditing and contract for purchase, etc.

3. Preliminary Engineering -- Determine project design parameters in sufficient detail that engineering specifications can be drawn up. With preliminary engineering drawings and specifications, project costing estimates can be made and checked against feasibility study estimates.

4. Permitting – Determine all necessary permits and permitting responsibilities. Perform preliminary site selection based, in part, on permitted use restrictions and requirements.

II. Background

Environmental Resource Recovery Group, LLC (EnRRG) entered into a contract with King County DNRP to study the feasibility of "**Anaerobic Digesters for King County Dairies".** Background for the feasibility study is taken from the **Contract Scope of Work**.

> *"The Biogas Project is an innovative project to produce energy, process heat and a usable soil amendment from dairy manure. Phase 1 will evaluate the feasibility of an anaerobic digester to process cow manure, capture methane to generate electricity and produce valuable by-products to improve soil health.*
>
> *The biogas project has multiple benefits. Under current regulations, manure from dairy farms is collected and stored in on-site lagoons. These lagoons release odors and methane, a powerful greenhouse gas that contributes to global warming. This project will capture the methane gas and use it to generate electricity. This will protect the environment by improving water quality, and by reducing waste, odors and greenhouse gas emissions. The project will enhance rural community and improve rural quality of life, produce alternative renewable energy, and enhance business opportunity and economic development in rural lands. The project enhances the county's agriculture and ESA programs, helps meet the county's goal of powering county operations with renewable energy, helps implement the county's clean air initiative and supports growth management objectives by maintaining a vital rural economy. The project is a partnership with King County Solid Waste Division, King County Water and Land Resources Division, King County Clean Air Program, the King Conservation District, Bonneville Environmental Foundation, Puget Sound Energy, Washington State Extension – Energy Office and City of Seattle.*
>
> *The primary goal of this study is to evaluate the feasibility of constructing one or more anaerobic digesters on dairy farms in King County for processing manure, producing electricity, process heat and commercially viable by-products. The ownership, operation and financing of the project will be elements of the feasibility study. This feasibility study is intended to guide future decision-making."*

The following excerpts from the initial proposal summarize EnRRG's approach to the feasibility study:

> Anaerobic digestion is a well-documented method for treatment of livestock wastes. It is an effective means for reducing odors, reducing manure solids and converting animal wastes into renewable energy. However, the adoption of anaerobic digestion by livestock producers in the United States has been rather slow, for a number of reasons – both economic and non-economic. The perceived benefits to be derived from the substantial investment in a digester by livestock producers just have not been great enough to stimulate (or force) investment of money, which they usually do not have, into such a facility.
>
> Attitudes are changing with regard to the incentives for using anaerobic digestion. The public is now expressing a strong positive attitude toward renewable energy and toward environmental stewardship. Most importantly, they are willing to contribute toward those ends. By doing so, the advantages of anaerobic digestion to the general public can be monetized in such a way that the burden of owning and operating digesters can be spread over all of those who benefit from them, not just the livestock producers.
>
> Environmental Resource Recovery Group, LLC is composed of individuals who have been involved with anaerobic digestion for many years and have been pioneers in the field. EnRRG is a group with diverse backgrounds but with the common interest of bringing solutions for problems facing agricultural producers that are workable, beneficial, and economically viable. EnRRG has developed a series of analytical tools that are used routinely for waste-to-energy project evaluation.
>
> Two copyrighted computer software products, "**Economic Feasibility of Biogas Recovery and Utilization**", and "**A Computer Model for Livestock Waste Nutrient Management**" are used to evaluate the economic feasibility of waste management and biogas projects in agriculture and agribusiness. Both are very producer-oriented,

pragmatic and effective in providing consistent analytical feedback as projects are explored and assessed. The first is used to evaluate the economic alternatives in biogas (anaerobic digestion) projects and the second is used in the preparation of Comprehensive Nutrient Management Plans.

Approach to the Study

This study was conducted in the same manner as if EnRRG were going to build, own and operate the project. Return on investment analysis, return on equity analysis and critical factor sensitivity analysis were used as project evaluation benchmarks. Emphasis was placed on collecting relevant information concerning this project and translating it into terms for evaluation by the computer software. The computer does not make decisions, but allows the researcher to quickly evaluate possibilities – some of which might never be considered without the computerized tool.

Information necessary for completion of this study falls into four categories: technical, economic, financial, and operational.

1. Technical – This includes information related to the characteristics of the waste stream, the technical aspects of digester design, weather factors and other design criteria. Mostly, this information will not be unique to King County dairies. However, this is the information necessary to complete Item 1 of the Feasibility Study – evaluating alternate technology and discussing the applicability of various technologies to the potential project in the county and is necessary for completion of the study.

2. Economic – Economic information includes all prices, costs and values assigned to components of the project. It includes the costing of the capital items for constructing the project, costing the operating components of the ongoing project over its useful life, and valuing the income and project revenue items. There are two phases – each equally important:

   - Identifying all of the potential cost and income items (including public and private incentives), and
   - Placing a value on each item that is provable, justifiable or assured.

3. Financial – Financial information includes such items as debt/equity balances, depreciation and tax alternatives, interest rates on debt, grants and credits available, financial organization of the project, ownership structure and other factors which affect ROE (Return on Equity) and returns to the stakeholders (stockholders). A project with strong economic feasibility can be improved by properly including debt in the capital structure. A project with unacceptable economic prospects might be improved using financing programs, but doing so may be inherently risky. In such a case it is the decision of the stakeholders whether the potential benefits justify the risk.

4. Operational – It seems an over-simplification to say that before a problem can be solved, one must know what the problem really is. But that fact is too often overlooked or lost in the enthusiasm to apply a "preconceived" solution. The practical aspects of the project include delineating the boundaries -- what is possible (legal, logistics, perceptions), and what is not possible, as well as assessing how well (benefit vs. cost) a possible solution works to meet the needs of the stakeholders. Most of the operational information that is collected will be used to determine what alternatives to evaluate with the computer model, rather than as direct input into that model.

III. Methodology

To complete the study, EnRRG relied on frequent communications with the various study stakeholders as to expectations as well as practical realities of potential project development. The intent was to ascertain as nearly as possible the real needs of the various parties as they might relate to a project of this type. Only if real needs are served without creating other problems can the parties be brought together for a project of common interest.

EnRRG, with the assistance of personnel from King Conservation District, visited about half of the dairymen of the Enumclaw Plateau at their farms. The project oversight team had set up a dairy oversight committee comprised of representative dairy producers from the Enumclaw Plateau to provide regular input to the study process. Three meetings were held with the dairy advisory committee. Cooperation from the dairymen and their interest in this project has been very good. By visiting with the producers independently as well as in a group setting, EnRRG was able to discover common items that must be considered in order for a digester project to be of value to them and to be supported by them.

Individual and group meetings were also held with the non-dairy participants in the project, to determine what each did and did not expect from the project and what each could or could not contribute to its success. Some aspects of the project are held in common but each participant had his own unique needs and expectations.

For the project to be successful, each participant must receive, and perceive, value greater than any cost or inconvenience resulting from that participation. Below is a summary of the information gleaned for the interviews and discussions.

Dairymen of the Enumclaw Plateau:

- Waste collection practices are nearly identical between farms -- daily scrape to collection tank and pump to lagoon, with no flushing. Bedding is done with sawdust or wood shavings. Waste collection methods are conducive to a digester project since there is no flushing which would add volumes of water and dilute the solids concentration. Additional water causes the need for more digester volume and increases the cost of transport to a central site. Preventing rainwater entry into waste storage tanks and controlling parlor flush water are issues of concern.
- Milk producers in King County have been under severe financial strain for an extended period and are very short on cash. They are not able to fund any significant capital projects, nor will they be in the foreseeable future.
- They are generally quite knowledgeable and enthused about the idea of a central digester, if it can save them money and help to solve the manure management dilemma.
- Handling manure is a major cost factor for them and takes a significant portion of their time, time they would consider to be non-productive.
- Most are second or third generation dairymen who have strong ties to the region. Herds are high producing. They want to stay in the dairy business if they can remain competitive and earn a living and, as in all of agriculture, that generally mean increasing the scale of operations.
- They are constrained by waste restrictions. Land for agronomic application of lagoon effluent is limited. Waste is being applied to land they do not own or control, just to get rid of it.
- New regulations, especially when phosphorus becomes the limiting nutrient, will only accentuate the problem.
- Disposal of mortalities is costly. They are looking for other alternatives for that problem.
- There is great interest in a digester project, but two conditions must be met: 1) it must solve the manure management problem, and 2) it cannot increase their operating costs.

Puget Sound Energy

- Interconnect requirements and estimated costs were investigated.
- Maps of power lines in the project area capable of handling the generator output.
- Cost estimates were obtained for interconnection.
- Power purchase agreement – PSE's expected price range for purchased power.
- PSE wants the renewable attributes (green tags).
- PSE can use the production tax credits, if the law is passed authorizing them.
- PSE may be interested in owning, leasing or maintaining the electrical infrastructure (interconnect and generation). If they own the electrical infrastructure and purchase biogas from the digester project, they would have direct ownership of the production tax credits and the green tags.
- They are not interested in equity participation in the digester portion of the project.

Seattle City Light:

- Primary interest is with the carbon credits (greenhouse gas reduction) produced by the project.
- SCL is willing to contract for acquisition of the credits, and perhaps make a forward payment (discounted) for a portion of the credits
- SCL is not interested in equity participation in the project.

King County Department of Natural Resources and Parks (DNRP), Solid Waste, and Water and Land Resources Division:

- Discussed other potential waste products to commingle with dairy manures in the digester project. (Solid Waste)
- City of Enumclaw might be a prospect for separated food and yard wastes since it has its own collection system and is located in close proximity to the proposed project area. (Solid Waste)
- Significant quantities of horse manure in the county, but most of it is distributed amongst numerous small landowners, which makes collection difficult. (Water and Land Resources)
- A digester project would likely support agriculture and protect farming interests. (Water and Land Resources)
- The natural environment could be enhanced and protected by such a project. (DNRP)

King Conservation District:

- Location, ownership and approximate size of each dairy farm of the county.
- Arranged and participated in on-farm visits with individual dairymen.
- Provided information related to waste management practices commonly used in the area.
- Outlined construction costs and costs for waste management equipment.
- Provided insight into the difficulties facing dairymen in the area of waste management and associated record keeping requirements.

Washington State University Energy Office

- Discussed digestion technology and modeling issues.
- Compared notes concerning waste conversion processes and other technical aspects of the project.

Bonneville Environmental Foundation

- Discussed the role of green tags in promoting renewable energy production and BEF’s activities in marketing green tags.
- BEF might be able to steer grant money to the project.

Exhibit 4 – Expectations and Potential Contributions

	Expectations (Needs)	Potential Contributions
Dairymen	Relieve Nutrient Management Burden Meet Environmental Mandates Expand Business Scale Increase Net Revenues	Supply the Manure User Fees (less than cost savings) EQIP Funds Other Grants No Capital at this time
Utilities	Meet Environmental Goals Capitalize on Incentives High Environmental Profile Increase Net Revenues	Purchase Electrical Power Purchase Carbon Credits Purchase Renewable Attributes Monetize Incentives to Cash Value
Public Interests	Facilitate Positive Directions Meet Environmental Goals Economic Development/Growth	Support/Facilitation with Permitting Funding Assistance Bureaucratic Barriers

Concepts and Terms used Throughout the Feasibility Analysis

Throughout this report and in the computer generated tables, certain term and concepts will be used repeatedly. Following is a brief explanation of some of those terms

Power Price

This is the value placed on the electricity generated by the project, either as a commodity added to the grid or by a reduction in on-farm purchases. The price is for wholesale market power with no incentives included.

Production Tax Credit

This is a federal tax credit for renewable energy production and is the same credit that applies for wind projects. At this time, the credit would not be applicable for a digester project using dairy waste. The current law specifically includes only poultry manure. The Senate Energy Bill of 2002 included energy produced from all manures, but that bill was not passed into law. It is assumed the PTC will be available for this project, but must be cognizant that it might not be. The current credit is 1.8 cents per kilowatt-hour, and is increased annually by the inflation rate. The credit is for only ten years of the project life. Since the PTC is a tax credit, for a tax-paying entity, the value is actually greater than 1.8 cents in pre-tax revenue, but only the after tax value has been used in the analysis.

Renewable Attributes

The “green tag” value for renewable energy is a voluntary premium paid by utility customers to encourage renewable power production. Two cents per kWh has been used as the value of green tags throughout the analysis. The green tags must be sold to customers before they have any value so there is an issue as to what value to place on the renewable attributes for this project. A strong argument can be made that the green tags from this project can attain full value: 1) they can be attributed to a specific and identified project which shows much higher public benefits as opposed to, say, a generic wind project, 2) local residents who benefit directly from this project could support it by purchasing its green tags, 3) a “bulk sale” of all of the green tags to a single customer is a distinct possibility.

Carbon Credits

The greenhouse gas remediation value of the project is reflected in the value of carbon credits. Reduced methane emissions to the atmosphere result from capturing methane that would otherwise be released from manure degradation in the anaerobic lagoons. The amount of carbon reduction is calculated within the computer model, based on industry standards. However, the actual greenhouse reduction must be audited and verified to obtain a tradable quantity. The value placed on the carbon credits is $4.00 per metric ton, based on the proposal of Seattle City Light, which is the likely purchaser of those credits. Alternatively, there is a developing world market for the carbon credits that are used to obtain compliance with the Kyoto Treaty. The ultimate value of carbon credits in world trade is a subject of much conjecture, ranging from a low of perhaps $1.00 per ton to a high of over $20.00 per ton.

User Fee

This is a fee to be paid by the dairymen who participate in the project. The dairymen have made it quite clear that they cannot participate in a project that costs them money – low milk prices have the entire industry in a loss situation. Any user fee must be less than the identifiable cost savings that result from participation in the project. EnRRG feels confident, after visiting personally with many of the affected producers, that will be the case. Current costs for handling manure – out of pocket, equipment, and management time – are substantial. Properly executed, a central project can reduce those costs significantly. A project can happen only if it helps the dairymen reduce their operating costs and produce milk more efficiently. The user fee included as income to the project is just enough to cover the cost of transporting manure to the digester and land-appling the liquid nutrients.

Solid Residuals

A digester will reduce the solids content of the waste stream by about one-half. The solids that remain after passing through the digester have value as fertilizer and soil amendment. They are eligible to use in the production of certified organic food, a market that has been growing an average of 20% per year. Biosolids are precluded from such use. The value to place on the residuals is critical to the financial performance of the project. They must be sold before they have any value, so a marketing effort is necessary in order to determine their true value. Solids obtained from a thermophilic process, because they have been subjected to higher temperatures, are considered to have greater value that those obtained from a mesophilic process. Thermophilic residuals are essentially pathogen-free and free from weed seeds (except for some clovers). Residuals have most of the attributes of peat moss, but contain nutrients which peat does not. Compared with compost, digester residuals also have the advantage of nutrient content. In addition, the three major concerns that commercial users of compost have identified – inconsistency, unknown origin and weed seeds – are not an issue with this product.

Locally marketed compost is sold for about $25 per ton. Peat moss is typically priced near $50 per ton FOB the bogs of Canada. For purposes of this analysis, a value of $20 per ton has been placed on the residuals of thermophilic digesters and $10 per ton for mesophilic digesters. Those values are very conservative and should easily be exceeded with an appropriate marketing effort.

Liquid Nutrients

The liquid component of the digester effluent contains a significant quantity of nutrients. The nutrients will be primarily used in local crop production. The value place on the liquid effluent is the commodity NPK value of competitive fertilizer. No premium is given to the “organic” nature of the nutrients.

Generator Repair and Maintenance

This is the estimated cost of maintaining the electrical generator equipment, including routine maintenance and machine rebuilds. One cent per kWh is used as an estimate for this cost item.

Digester Operations

This represents the costs of operating the digester, including repairs and maintenance and staffing. In the case of a central digester, professional full-time employees will operate the project. For on-farm digesters, a value is given to the time of the farm operator. For the central project, which includes the water treatment process, a professional employee will provide compliance services for the dairymen to meet their nutrient management regulations.

Solids Residuals Handling

This is the cost of handling the solid residue separated from the digester effluent. The residue must be cured for a period of 30-60 days before it is ready to sell, and turned once during that time much like compost. A value of $5.00 per ton is included for the cost of operating the separation equipment and handling the solids at the digester site prior to sale. No bagging costs are included. If the solids are bagged, an incremental charge will be added to selling price.

Water Treatment

The costs associated with processing digester effluent water into two streams – 1) nutrient dense and 2) re-use or discharge quality – is included in this category. By reducing the liquid to be land applied by a factor of 20, the economics of transporting nutrients away from the region becomes possible. Operating costs for the UFRO (ultrafiltration/reverse osmosis) process include maintenance of the membranes and costs for operating pressure pumps. Technical breakthroughs in recent years have reduced the costs of membrane separation to the point where such technology can be justified in this project. According to the manufacturer, the process that requires 100 psi with current technology would have required 600 psi just a few years ago. The manufacturer estimated operating cost at under $1.00 per thousand gallons of re-use or discharge water. A conservative cost factor of $1.50 per 1000 gallons is used in this analysis.

Manure Transport

Managing the procedures and costs for collecting manure from the individual farms and transporting it to the central digester site is a critical issue for the success of a centralized project. This feasibility analysis assumes manure will be trucked from the farms using tankers, much like transporting milk. There might be some use of pipelines for such purpose if the project is implemented, and that would reduce costs. Costs for manure transport are covered in detail in Appendix C and Appendix E, and a spreadsheet is available to evaluate transport alternatives. Since the average haul distance is so short (about 2.5 miles), driver time is a greater cost component than truck operating cost. In the analysis, the assumption is made that the tractors and tankers used for this purpose will be "previously owned" and that double trailers will be pulled, thus reducing the number of trips. Location of the digester site relative to the participating dairies is a consideration, as is the ability to prevent rainwater from entering the manure collection facilities at the farms. Transporting excess water affects both the cost of transport and the operation of the digester.

Residual Liquid Transport

This is the cost of land application of the residual liquid after concentration by the reverse osmosis process. Spreader trucks are employed to apply the fertilizer in the manner of a commercial fertilizer operation. Land application costs are based on a rate of $15 per thousand gallons, using a 3,000-gallon spreader truck.

Throughout the rest of this report, the following guidelines will prevail:

A project is considered to be feasible if it:

1. Is technically sound and stable.
2. Meets the needs of the affected parties.
3. Demonstrates acceptable financial returns.

The needs of the principal parties are:

1. Dairymen – Solve the waste management dilemma, without adding costs.
2. Utilities – Produce renewable energy and environmental financial incentives.
3. Public Interests – Provide environmental security and economic growth.

IV. Technology Assessment

Economic Assessment of Alternate Technologies

As part of the feasibility study of digesters for dairies of King County, an assessment of the economics of the various digester technologies used in different sized dairy operations was carried out.

There is not a firm distinction between different technologies that can be employed for digestion of animal wastes. In practice, many suggested designs employ elements of various technologies. For purposes of this study, two distinctions were made – plug flow versus mixed digester, and mesophilic versus thermophilic temperature range.

A basic plug flow digester is a covered channel where waste enters one end and exits the other. Relatively solid "plugs" of material stay together as they are pushed from one end to the other by newly entering material in a first-in, first-out manner. The average retention time is a function of the capacity (length) of the channel and the amount of material added daily. A mixed digester is a containment vessel to which material is added in intervals. A mixing mechanism continuously stirs the material within the vessel. As new material is added, other material is expelled by volumetric displacement. Different schemes are used to retain solids within the vessel. Reduced solid content liquid is expelled and solids are separated from the liquid portion

Mesophilic and thermophilic refer to different temperature ranges in which the digesters operate. At different temperatures, different bacteria predominate and with different results. From an economic standpoint, the primary differences are these: 1) thermophilic activity is faster and requires a shorter residence time to attain the same level of solids destruction (and consequent gas production), 2) thermophilic requires more heat to bring incoming material up to temperature and to maintain temperature of the digestion vessel, 3) thermophilic (because of the higher temperature) has a greater destruction of pathogens and weed seeds.

For purposes of the comparative assessment, three technologies were differentiated as shown in the table below. From the standpoint of economic evaluation, the most important single differentiating item is the different value for the organic residuals. Justification for the higher value for the thermophilically derived residues is the higher level of pathogen destruction and weed seed destruction, which makes the residuals more valuable when marketed in a manner to obtain maximum value.

		Plug	Mixed	
		Flow	Mesophilic	Thermophilic
Retention	days	30	30	15
Temperature	deg F	95	95	135
VS Conversion	Ft3/# VS	5	5.5	6
Residuals Value	per ton	$10	$10	$20

The different factors were entered into the economic simulation program and modeled over a range of enterprise sizes. In addition to the differences shown in the above table, the facility cost for the plug flow alternative was calculated differently from the two mixed digester alternatives. The mixed digesters were considered to use above ground glass-fused-to-steel vessels and the plug flow digester would be constructed in-ground from concrete, priced at local rates.

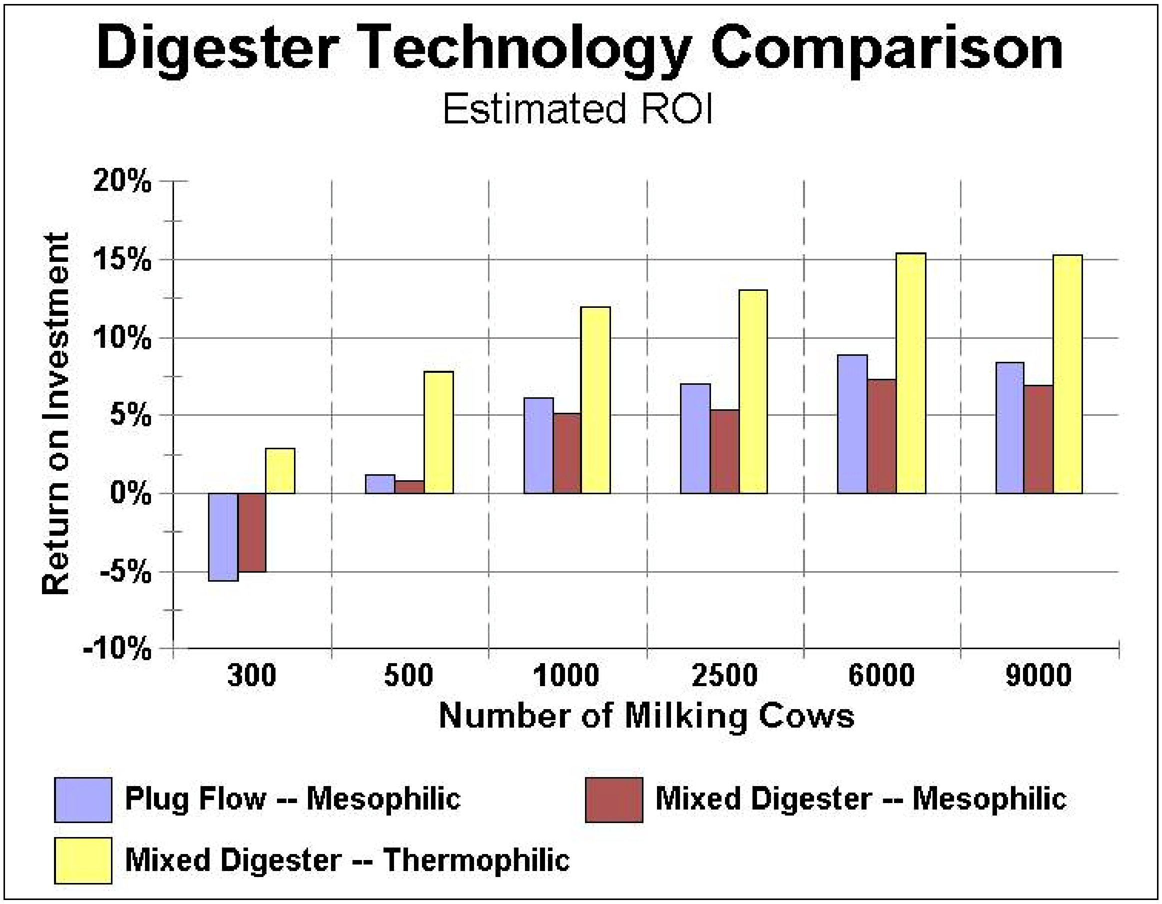
The chart in Exhibit 5 illustrates the comparative economics of the three defined technologies over a range of herd sizes. The economic advantage for the thermophilic mixed technology across the spectrum of enterprises is a function of the higher value for the organic residuals and the reduced capital cost associated in a smaller digester vessel needed for the shorter retention time.

Whether or not the simulated results will be realized depends greatly on the individual operation. For example, it is doubtful that residuals from a small thermophilic digester would be able to command their higher intrinsic value, due to the required marketing effort required. A small-scale digester would probably be managed entirely by the owner who would not have the marketing skills necessary to obtain the higher value.

For a similar reason, the thermophilic technology is probably not appropriate for a small scale, owner managed digester, due to the higher level of complexity involved.

Details of the alternative technology assessment are presented in Appendix A.

Exhibit 5 – Estimated Digester ROI by Technology and Enterprise Size



V. Evaluation of Single Farm and Central Digesters

The next phase of the study is to evaluate and compare in greater detail the feasibility of a farm-scale digester with a centralized digester. The farm scale digester was assumed to be a 500-cow unit, while the centralized digester was sized at 6075 cows. Of the 15 producers from the Enumclaw Plateau considered likely to participate in a digester project, 6075 is the approximate total number of milking cows. The 500-cow digester could represent one dairy from the region or a combination of 2 or more adjacent farms.

More detailed modeling was done specifically for the two sizes of operation, with the centralized digester having the additional characteristic of a manure transport function -- both capital cost and operating costs.

The table below shows the results of the more detailed modeling. Expected ROI is shown for each of the three technologies and for the two specific cases. In addition, a sensitivity analysis of net revenue versus ROI is included. In the sensitivity analysis, project capital cost is held constant while net revenue is varied over a range of 50% to 150% of base-case proforma.

For the single farm digester, plug flow and mixed/thermophilic show similar returns, while mixed/mesophilic lags badly. Mixed/mesophilic has similar returns as plug flow but with a higher capital cost. Thus the lower ROI.

For the centralized project, the mixed/thermophilic alternative shows a significant advantage over the other two.

Summary of ROI for All Cases Studied

	Income % of Expected				
	50%	75%	100%	125%	150%
500 PF	-4%	-1%	2%	4%	6%
500 MM	-10%	-7%	-5%	-3%	-2%
500 MT	-4%	-0%	3%	5%	8%
6075 PF	1%	5%	9%	13%	16%
6075 MM	-0%	4%	8%	11%	14%
6075 MT	5%	11%	16%	20%	25%

The question whether the two digesters meet the requirements necessary to be considered feasible in King County can be addressed at this time. The table shows how each fares in the three tests of feasibility.

Technically Sound and Stable

Both digesters meet the criterion of being technically sound and stable. All technologies are well proven and, properly designed and operated, will perform as expected

Criterion	Single Farm	Centralized
1. Technically sound and stable	Yes	Yes
2. Needs Served		
Dairymen	No	Yes
Utilities	No	Yes
Public	No	Yes
3. Financial Return	No	Yes

Meeting the Needs

A farm level digester cannot be considered to meet the needs of the dairymen because it does not solve their biggest problem -- management of nutrients. Nutrients are not destroyed during anaerobic digestion. In the digester, nitrogen is transformed into a less volatile form than in raw manure. Reduced nitrogen losses to volatilization means more nitrogen to apply to cropland in the mandated nutrient management plan. With current management practices, approximately 45% of the nitrogen that is excreted by dairy cows volatilizes to the atmosphere before land application. For every 1000 pounds of excreted nitrogen, only 550 pounds must be accounted for in the nutrient management plans of the dairymen. If using a digester reduces the volatilization to 25%, then 750 pounds of nitrogen would have to be accounted for in the plan.

With a large enough local demand for fertilizer, the additional nitrogen would be beneficial. But that is not the case in the Enumclaw Plateau. Excess nitrogen is a liability. More nitrogen means more acres of land needed for agronomic use of the nutrients. The most critical issue facing producers – disposal of fertilizer nutrients -- will be compounded by the digester, not alleviated. Selling separated digester solid residuals off-site would have no advantage to the current practice of separating the solids from fresh manure.

With the centralized digester, and using membrane technology, nutrients can be concentrated in the solid residue and the liquid portion sufficient that both can be economically transported from the region. Therefore, dairymen can be completely separated from the nutrients of their cows' manure.

Even though, in the economic analysis, the same credit for environmental incentives was given to the farm level digester as for the centralized digester, in actuality it is unlikely that would be the case. There is just not enough "critical mass" to stimulate the utilities to expend the required effort in labor overhead to document and pursue the prospective incentive values. For example, the overhead to justify carbon credits would be essentially the same for a single farm as for a centralized project, and the annual return from the small digester would be a small fraction of the centralized project. For the centralized project, there is sufficient scale to allow the utility partners to obtain full value for the environmental incentives.

While it could be argued that public interests would be served by the reduced odor attributed to a single farm, in actuality the small reduction would probably not be noticed. Since the nutrient load is not reduced, there would not be a prospect for water quality improvement. In the case of the collective project, both odor and water quality issues would be essentially eliminated.

Financial Returns

Even when given credit for environmental incentives that would probably not be attainable, the farm level digester shows very marginal financial returns, at best. Estimated returns are less than the currently low cost of borrowed money. The projected ROI for the central project is high enough that it should attract investment capital.

Conclusions:

1. **A farm level digester is not considered a feasible alternative in King County.**
2. **A centralized digester meets all of the criteria for feasibility.**

Detailed analyses for a centralized digester/ dairy waste conversion project continue through the following sections of this report.

VI. Site characteristics

In considering a site for a central digester to serve the needs of the dairy producers in King County, the primary criteria to consider include: 1) transportation costs for inbound material, 2) access to the electrical grid, 3) land requirements, 4) location of non-compatible entities, 5) availability of "nutrient sinks", and 6) space for associated business activities.

Inbound Transportation Costs

It is important to the financial success of the project that one of the major cost components that accrues each day be held to its lowest practical level. Inbound transportation cost for bringing the manure from each individual farm to the central digester is determined largely by 1) the time required to load and unload each trip, and 2) the travel distance. The dairies of the Enumclaw Plateau are located within a relatively concentrated area. The central digester site should be located within the boundaries of the animal concentration. Methods for estimating inbound transportation cost are shown in Appendix C. Minimum transportation cost areas are highlighted in the yellow of Exhibit 6 and Exhibit 8.

Exhibit 6 – Estimated Inbound Transport Costs ($/Cow)

Estimated Transportation Costs to Various Grid Locations

SE St														
368	6.5	$56	$53	$50	$46	$45	$45	$45	$45	$45	$46	$48	$50	$52
376	6	$53	$50	$47	$43	$43	$42	$42	$42	$42	$43	$45	$47	$49
384	5.5	$50	$47	$44	$40	$40	$39	$39	$39	$39	$40	$42	$44	$46
392	5	$47	$44	$41	$38	$37	$36	$36	$36	$36	$37	$39	$41	$43
400	4.5	$44	$41	$39	$35	$34	$34	$33	$33	$33	$34	$36	$38	$40
408	4	$42	$40	$37	$33	$32	$32	$32	$32	$32	$32	$34	$36	$39
416	3.5	$41	$38	$36	$32	$31	$31	$31	$31	$31	$31	$33	$35	$37
424	3	$41	$38	$35	$32	$31	$31	$31	$30	$30	$31	$33	$35	$37
436	2.25	$42	$39	$36	$33	$32	$32	$32	$32	$32	$32	$34	$36	$38
440	2	$42	$40	$37	$34	$33	$33	$33	$32	$32	$33	$34	$36	$39
448	1.5	$44	$41	$39	$35	$35	$34	$34	$34	$34	$34	$36	$38	$40
456	1	$46	$44	$41	$38	$37	$37	$36	$36	$36	$37	$38	$40	$43
464	0.5	$49	$46	$43	$40	$39	$39	$39	$39	$39	$39	$41	$43	$45
472	0	$51	$49	$46	$42	$42	$41	$41	$41	$41	$42	$44	$46	$48
		0	0.5	1	2	2.5	2.75	3	3.5	4	4.5	5	5.5	6
	Avenue S	164	172	180	196	204	208	212	220	228	236	244	252	260

Calculated inbound transportation cost for bring all of the waste from likely participants"
to each grid location within the area. Shows bullseye of minimum cost locations for transport cost.

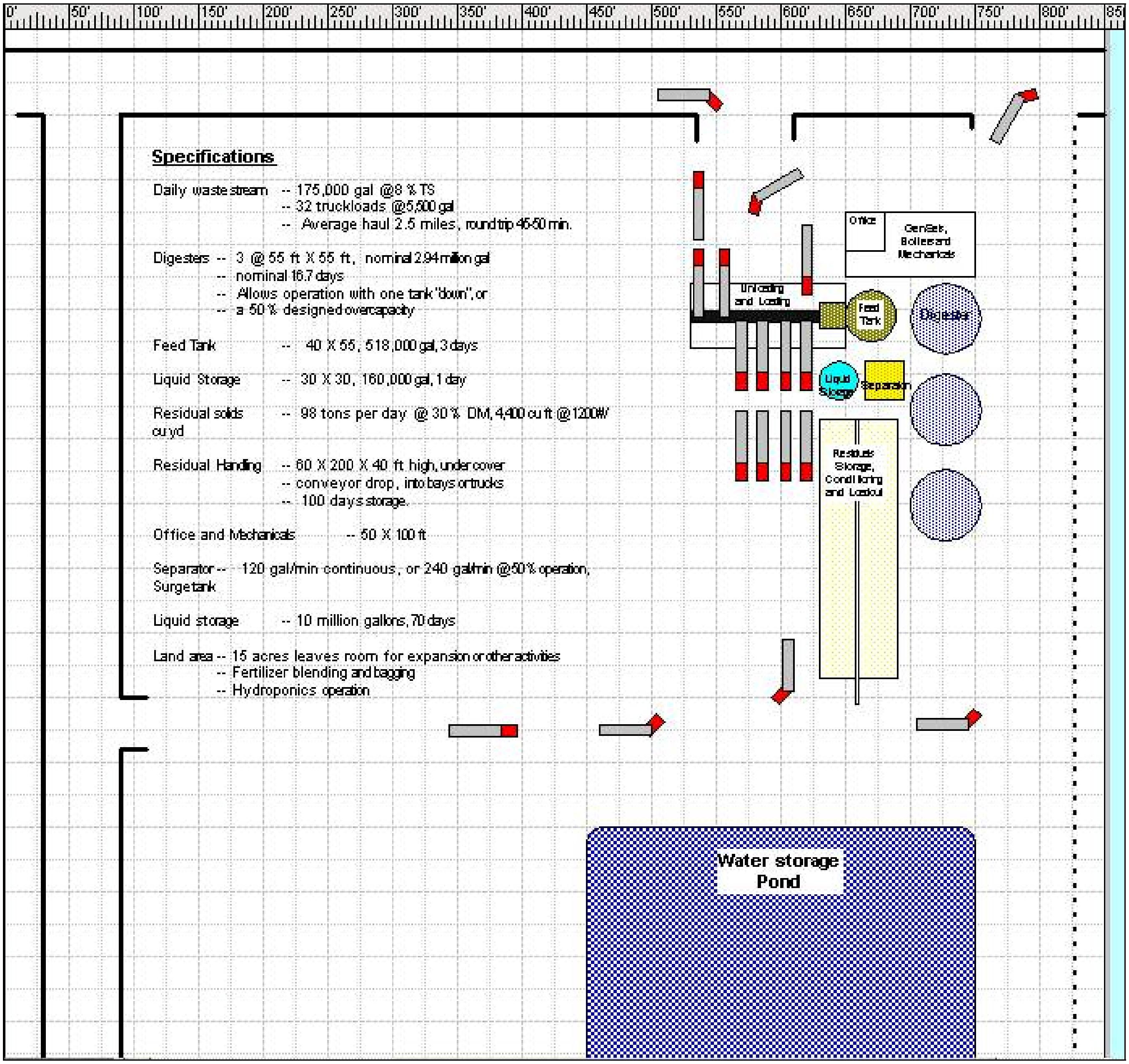
Access to the Grid

Electric lines are expensive to construct, so it is beneficial to locate the project where existing lines can be utilized with a minimum of new construction. The red lines in Exhibit 8 indicate the location of power lines with sufficient capacity. Locating the project near existing power lines will minimize interconnection costs.

Land Requirements

The schematic site drawing in Exhibit 7 shows one potential layout for a centralized digester. The drawing shows that the project could be located on a minimum of about 8 acres. But allowing for a bit of extra space for expansion and working area, fifteen acres would seem to be an adequate space for the project.

Exhibit 7 – Centralized Project Site Layout


0' 50' 100' 150' 200' 250' 300' 350' 400' 450' 500' 550' 600' 650' 700' 750' 800'
Specifications
Daily waste stream -- 175,000 gal @8 % TS
-- 32 truckloads @5,500 gal
-- Average haul 2.5 miles, round trip 45-50 min.
Digesters -- 3 @ 55 ft X 55 ft, nominal 2.94 million gal
-- nominal 16.7 days
-- Allows operation with one tank "down", or
-- a 50 % designed overcapacity
Feed Tank -- 40 X 55, 518,000 gal, 3 days
Liquid Storage -- 30 X 30, 160,000 gal, 1 day
Residual solids -- 98 tons per day @ 30 % DM, 4,400 cu ft @1200#/cu yd
Residual Handling -- 60 X 200 X 40 ft high, under cover
-- conveyor drop, into bays or trucks
-- 100 days storage.
Office and Mechanicals -- 50 X 100 ft
Separator -- 120 gal/min continuous, or 240 gal/min @50 % operation, Surge tank
Liquid storage -- 10 million gallons, 70 days
Land area -- 15 acres leaves room for expansion or other activities
-- Fertilizer blending and bagging
-- Hydroponics operation
Office
GenSet, Boilers and Mechanicals
Unloading and Loading
Feed Tank
Digester
Liquid Storage
Separation
Residuals Storage, Conditioning and Loadout
Water storage
Pond

Non-compatible Entities

Care should be taken not to locate the project where conflict is likely to be generated, either with neighbors, other businesses or with incompatible land usage. Attention to appropriate zoning will help to minimize the probability of conflicts, but does not guarantee that problems will not be forthcoming. A larger site that allows for landscaping buffers and any other mitigation steps is advisable.

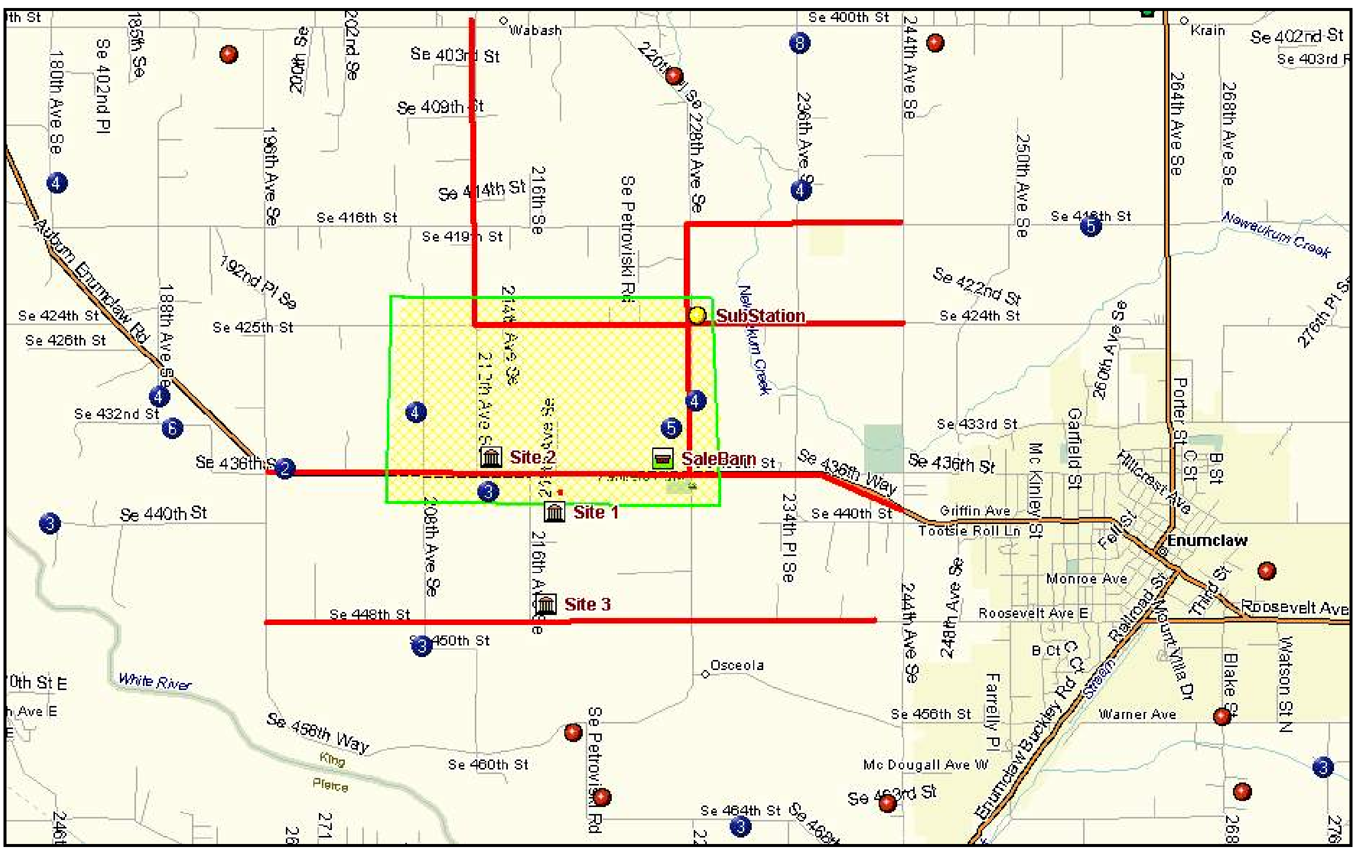
Nutrient Sinks

The availability of nutrient sinks, land areas where great quantities of nutrients can be utilized in an agronomic manner, would be a positive attribute. However, in the Enumclaw Plateau such an area does not exist. Most of the land in the area is either grassland or hay land. There is no large area of high nutrient-use cropland.

Associated Business Development

One of the public interest goals for a digester project is to stimulate economic growth and retain jobs. The project has a potential to bring in associated business activities which utilize some of the co-products of the digestion process, such as: 1) a blending and bagging operation for organic fertilizers, 2) organic and/or hydroponic vegetable production and 3) mushroom production. Additional land area for such economic growth should be considered.

Exhibit 8 – Prime Location for Central Digester



Three sites have been identified within the primary area of interest which are, or might be, for sale and which meet most, it not all, of the necessary site characteristics. Those sites are shown on the map in Exhibit 7, in relation to the dairies that are identified by colored dots.

VII. Economic Analysis of Central Digester/Waste Conversion Project

Following is a description and detailed analysis of a centralized dairy waste digester and waste conversion project that addresses the needs of the project participants.

For the dairymen – it frees them of the waste management burden at a lower total cost than they currently experience, and permits herd expansion if desired.
For the utilities – it produces renewable energy and maximizes financial incentives.
For the public – it offers a high level of environmental security, both air and water, for a large portion of the county. It presents an opportunity for economic growth.

The project uses technology that is well proven and represents an acceptable return on capital for prospective investors.

The project is innovative, both in its application of technology to solve problems and create value and in its ability to bring together dissimilar parties to a cooperative venture which benefits all and harms none.

Key aspects of project include (refer to the flow chart of Exhibit 1, page 3):

- Manure is collected daily from all of the participating dairies and transported to a central site. Transport is assumed via tanker truck. A pipeline connecting some of the farms to the central site might be a viable alternative.
- Once at the digester site, manure is degraded by anaerobic digestion into biogas and a benign (essentially odor-free and pathogen-free) liquid effluent.
- Suspended solids are removed from the liquid effluent and further processed into organic fertilizer.
- Dissolved solids are removed from the separated liquid fraction using ultrafiltration and reverse osmosis. Two liquid streams are created by UFRO, one of concentrated fertilizer nutrients and the other of re-use or discharge quality water.
- Concentrated liquid nutrients are land-applied via spreader truck, first to the participating dairymen as desired and then to paying customers. The high nutrient density of the concentrated liquid allows economical export from the region, to cropland where it can replace commercial fertilizer.
- It is possible to further concentrate the liquid nutrients and blend them into the solid component, eliminating the need for land application of any nutrients other than to the dairies. The economics of that option need to be explored.
- All nutrient management compliance activity and record keeping can be performed at the central site, completely separating the dairymen from waste management constraints and costs.
- Any user fee paid by dairymen for participation in the project will represent a fraction of the identified cost savings to them.
- Biogas is converted to electricity through an engine generator and added to the grid.
- Environmental incentives for the utility partners -- including carbon (greenhouse gas reduction) credits, renewable attribute (green tags) and a Federal Production Tax Credit (if passed into law) -- add value to the project.
- Puget Sound Energy is a ready purchaser for the power, green tags and the PTC. Seattle City Light is interested in the carbon credits. Their participation in the project is based on these benefits.
- The separated solid component (organic residuals) is a high value fertilizer and soil amendment that can be used in organic food production. Its actual value must be determined through marketing but, intrinsically, it is a higher value product than peat moss or high quality compost, neither of which have significant nutrient value.
- No raw manure or lagoon concentrate will be applied to grass and hay land in the region, eliminating the possibility for surface runoff or odors associated with land application. Air and water quality are secured.
- Co-products of the digestion process present opportunities for additional economic activity including organic food production (solid residues, liquid nutrients, waste heat), blending and bagging of organic fertilizer for home use (solid residues), and mushroom production (solid residues).

Membrane Technology

The process of reverse osmosis is well known in the water treatment industry. Pressurized water is forced against a membrane that contains very small pores. Water molecules are able to pass through the membrane but dissolved salts are not. Two liquid streams are created, one of pure water and the other with a higher concentration of dissolved salts. The process of ultrafiltration is essentially the same as reverse osmosis, but with larger pore sizes, and is often used to condition water ahead of the reverse osmosis stage.

Reverse osmosis is the process used to desalinize seawater into drinking water. In the past, the process has been costly and used only where no less costly alternative existed. There are two primary costs for the membrane stage – membrane replacement and power to pressurize the water. Recent technical advances have reduced both cost items. Membranes are less costly and longer-lived and the water pressure required for operation has dropped dramatically. One manufacturer reported a process that required 600 psi a few years ago can now be accomplished with only 100 psi. Power requirements and costs are reduced accordingly. The manufacturer estimates the operating cost for the membrane stage of this project at under $1.00 per thousand gallons of re-use or discharge water. That compares with perhaps $5-6 in the not too distant past.

Adding the UFRO stage transforms this project from a "digester project" into an "integrated waste conversion project" and makes it much more valuable to the dairy producer and to the public interests. The utility interests are not affected since they obtain maximum value from the digester alone. Costs added by the UFRO stage are returned many times over by reduced transport cost and land application costs of dilute liquids. Value is added to the public interest sector by increasing the level of environmental security.

Economic Analysis of the Central Project

The copyrighted economic simulation model "**Economic Feasibility of Biogas Recovery and Utilization**" was used to perform economic feasibility analysis of the centralized digester/waste conversion project. Highlights of the analysis are presented here and greater details are available in Appendix C. The model is interactive and project participants have been given the opportunity to test various scenarios during previous meetings. The model will be maintained so that additional interactive scenario testing can be conducted in the future.

Exhibit 9 is a table of "adjustment factors" that allow customization of the digester project by adding elements that differentiate it from other projects. Line items can be added to capital cost, revenues and operating costs. The "number" column contains either user specified input or values calculated within the model that will vary as alternative solutions are examined.

Included in the capital costs section are the investments in rolling stock (both for waste collection and land application), solids handling, membrane technology and site related investment. In the income section, unit values are entered and applied to variables calculated within the model. The same applies for the operating cost section except that facility operating cost is an externally entered value.

The next table, Exhibit 10, is the Summary report for the economic analysis model. It contains a variety of summarized information about the base solution, including capital expenditures, net revenues, and investment analysis and project descriptive data.

Exhibit 9 – Adjustment Worksheet for Project Customization

Adjustments to Income, Expense and Capital Costs

Dairy --- Thermophilic 13.84%

	Number			Cost/Value Each	Amount
Capital Cost					
Transport Trailers	15		@	$15,000	$225,000
Transport Tractors	5		@	$25,000	$125,000
Fertilizer Plant Fixed	1		@	$500,000	$500,000
Fertilizer Plant Variable	36,568	Tons	@	$20	$731,352
Secondary Water Treatement	1			$500,000	$500,000
Site and Preparation	1		@	$500,000	$500,000
PSE Interconnect & Lines	1		@	$450,000	$450,000
Spreader Truck	2		@	$25,000	$50,000
				Total	$3,081,352
Income					
Processing Fee	6,075	Milkers	@	$40.00	$243,000
Organic Residuals Sale	36,568	Tons	@	$20.00	$731,352
Renewable Energy PTC	10,385,992	KWHr	@	$0.018	$186,948
Carbon Credits	38,576	M Tons	@	$4.00	$154,304
Renewable Attributes Premium	10,385,992	KWHr	@	$0.020	$207,720
Nutrient Rich Water (75%)	1,681	000 G	@	$80.00	$134,483
				Total	$1,657,807
Operating Cost					
Residuals Handling (not bagging)	36,568	Tons	@	$5.00	$182,838
Facility Operation exc GenSet	1			$350,000	$350,000
Transport Cost	251,884	Tons	@	$0.60	$151,131
Water Processing Cost	42,586	000 G	@	$1.50	$63,879
Liquid Application	2,241	000 G	@	$15.00	$33,621
				Total	$781,469

Exhibit 10 – Project “Base Case” Summary Report

ECONOMIC FEASIBILITY OF BIOGAS RECOVERY AND UTILIZATION

Project Name: **King County Central Digester with UFRO**

Dairy --- Thermophilic 13.84%

Project Summary

This project uses a heated digester at 135 degrees F. It requires a 1482 KW generator. Electricity which is sold is valued at $0.035 per Kwh. In addition, 0% of the recoverable generator heat is utilized at a value of $5 per MMBtu. The project requires $7592078 capital investment and returns $1135988 annually giving a 13.8% return on investment and a payback in 8.6 years at 5.5% interest.

Project Description

State:	Washington	
Climate Zn:		
Enterprise:	Dairy	
Enterprise Units:	6,075	Milkers
Digester Type:	Thermophilic	
Daily VS	82,013	lbs
TS %	8.00%	
Daily Biogas	492	000 Ft3
Daily Methane Ener	295	MMBtu
Ave Elect Prod	1186	KW
Digester Vessel	2,503	000 gal
Fertilizer Sales	36,568	Tons

INVESTMENT ANALYSIS

Capital Costs

Digester	2.50	M gal	
Generator	1482	Kw	
Digester & CoGen			$2,986,033
Fertilizer Plant			$0
Capital to Force			$0
+/- Other Capital Items			$3,081,352
Engineering&Contig			$1,524,693
CHP Credit	No		$0
Total Capital Costs			$7,592,078

Using Worksheet

Returns

			Monthly	Annual
Offset Electric Cost	$0.065	/kwh	$0	$0
Sale of Electricity	$0.035	/kwh	$30,292	363,510
Offset Demand Charge	$2.00	/kw	0	0
Recovered Heat Value			0	0
Gas - On-Site Use	$5.00	/MBtu	0	0
Gas - Sale	$4.00	/MBtu	0	0
+/- Income to Balance			0	0
+/- Other Value			138,151	1,657,807
Total Savings			168,443	2,021,317
GenSet O&M				(103,860)
+/- Adjustments			(65,122)	(781,469)
Net Benefit			$94,666	$1,135,988

Investment Analysis

R.O.I. (Internal Rate of Return)		**13.84%**
Payback Years @	4%	7.93
@	5.5%	8.56
@	8%	9.94
Net Present Value 20 yr	5.5%	$5,983,413

What If ????

	R.O.I.	Payback Yr @ 5.5%
Decrease Capital Costs by 25%????	19.37%	6.02
Increase Net Benefits by 25%????	18.02%	6.50
Both the Above????	24.63%	4.65

Exhibit 11 summarizes the revenue components of the project into volume and price. This project has seven distinct revenue items resulting from the transformation of cow manure (a liability) into assets. All of the unit values except the number of cows are calculated within the model. The number of cows is one of the primary drivers of the analysis, as it defines the enterprise size and the amount of manure available to the digester. All of the unit values are assumptions, which can be varied through "what-if" testing to determine their sensitivity on project ROI. Exhibit 12 is pro-forma operating compilation of revenues, expenses and capital components. It shows the makeup in terms of total dollars and as a percentage of total. The relative importance of each income component is illustrated.

Exhibit 11 – Volume and Unit Value of Income Items

Income Items -- Quantity and Price				
	Units		Value	Annual
Electicity Sale	10,386	MWh @	$35.00	$363,510
Production Tax Credit	10,386	MWh @	$18.00	$186,948
Renewable Attributes	10,386	MWh @	$20.00	$207,720
Carbon Credits	38,576	M Ton @	$4.00	$154,304
User Fee	6,075	Cows @	$40.00	$243,000
Solid Organic Residuals	36,568	Tons @	$20.00	$731,352
Liquid Organic Fertilizer	1,681	000 gal @	$80.00	$134,483
				$2,021,317

Exhibit 12 – Summarized Operating Statement and Project Capital

Proforma Investment and Operating Statement

Dairy --- Thermophilic 13.84%

Income

Electricity		
Net metered Power	$0	0%
Demand	$0	0%
Sale to Utility	$363,510	18%
Power Based Incentive		
Production Tax Credit	$186,948	9%
Renewable Attributes	$207,720	10%
Carbon Credits	$154,304	8%
User Fee	$243,000	12%
Nutrient Value		
Residual Solids	$731,352	36%
Liquid Fraction	$134,483	7%
Total Revenues	$2,021,317	100%

Expense

Operations		
Genset R&M	$103,860	12%
Digester Operations	$350,000	40%
Solid Residuals Handling	$182,838	21%
Water Treatment	$63,879	7%
Transportation		
Waste Inbound Hauling	$184,751	21%
Total Expenses	$885,329	100%

Net Revenues

Net Revenues	$1,135,988	56%

Capital

Digester & Equipment	$1,965,102	26%
GenSet & Interconnect	$1,470,931	19%
Solids Handling	$1,231,352	16%
Rolling Stock	$350,000	5%
Land and Development	$500,000	7%
Engineering & Conting.	$1,524,693	20%
Other	$550,000	7%
Total	$7,592,078	100%

Exhibit 13 – Project Sensitivity

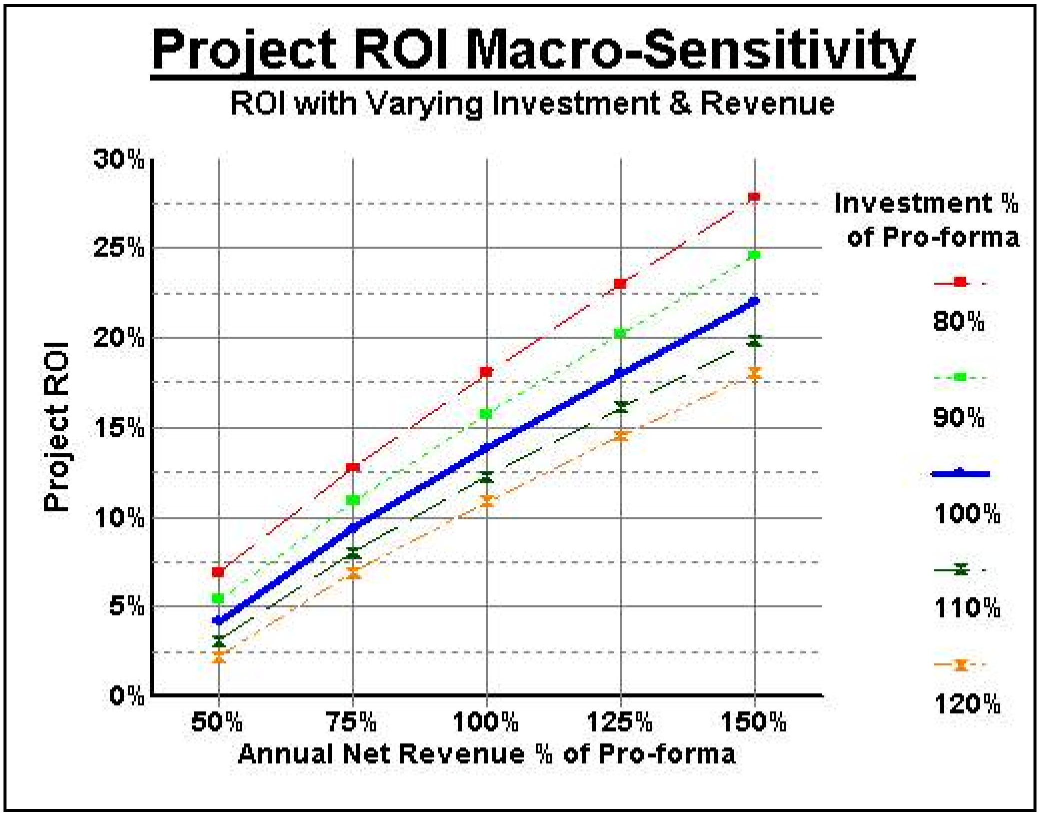


Exhibit 14 -- Micro-Sensitivity Analysis by Economic Factor

Economic Micro-Sensitivity of Key Project Factors

Dairy --- Thermophilic 13.84%

Factor	Base Value		Change By	Effect on Income	Effect on Capital	Effect on ROI	Value for ROI Target** 10%
Project Size	**6,075**	Milkers	**1200**	$293,528	$532,223	2.96%	4588
External Power Price	**$0.035**	Per Kwh	**$0.005**	$51,930		0.78%	$0.012
Renewable Attributes Credit	**$0.020**	Per Kwh	**$0.005**	$51,930		0.78%	($0.003)
Carbon Credits	**$4.00**	Per Ton	**$0.50**	$19,288		0.29%	($2.31)
Organics Sale Price	**$20.00**	Per Ton Bulk	**$5.00**	$182,838		2.72%	$13.34
Manure Transport Cost	**$0.60**	Per Ton	**$0.10**	($25,188)		-0.38%	$1.57
User Fee	**40.00**	Per Milker	**$5.00**	$30,375		0.46%	$4.32
Liquid Fertilizer	**$80.00**	Per 000 Gal	**$10.00**	$16,810		0.25%	($65.18)
Gas Production Factor	**6.00**	Ft3 / #VS	**0.50**	$67,385	$86,451	0.81%	4.04
GenSet Efficiency	**35%**	Annual	**1%**	$18,695	$29,640	0.22%	20%
Project Total Capital		One Time	**$500,000**		$500,000	-1.07%	$2,161,019
Project Net Revenue		One Time	**$50,000**	$50,000		0.75%	($243,840)

Exhibit 15 – Micro-Sensitivity Analysis, Goal Attainment

Economic Micro-Sensitivity of Key Project Factors

Factor	Base Value		Value of Factor Necessary for Specified ROI Target ** 6.0%	8.0%	10.0%	Base 13.8%	15.0%	20.0%
Project Size	6,075	Milkers	3639	4080	4588	6,075	6709	9137
External Power Price	$0.035	Per Kwh	($0.010)	$0.000	$0.012	$0.035	$0.045	$0.077
Renewable Attributes Credit	$0.020	Per Kwh	($0.025)	($0.015)	($0.003)	$0.020	$0.030	$0.062
Carbon Credits	$4.00	Per Ton	($8.22)	($5.35)	($2.31)	$4.00	$6.04	$15.70
Organics Sale Price	$20.00	Per Ton Bulk	$7.07	$10.14	$13.34	$20.00	$22.16	$32.35
Manure Transport Cost	$0.60	Per Ton	$2.57	$2.03	$1.57	$0.60	$0.29	($1.02)
User Fee	40.00	Per Milker	($37.38)	($17.75)	$4.32	40.00	$53.38	$111.79
Liquid Fertilizer	$80.00	Per 000 Gal	($199.23)	($134.95)	($65.18)	$80.00	$126.64	$337.84
Gas Production Factor	6.00	Ft3 / #VS	2.08	2.91	4.04	6.00	6.74	10.31
GenSet Efficiency	35%	Annual	6%	12%	20%	35%	42%	69%
Project Total Capital Deviation	$0.00	One Time	$5,877,447	$3,727,033	$2,161,019	$0.00	($434,808)	($2,026,841)
Project Net Revenue Deviation	$0.00	One Time	($470,389)	($360,911)	($243,840)	$0.00	$82,150	$443,963

** All other factors remaining unchanged at their base value.

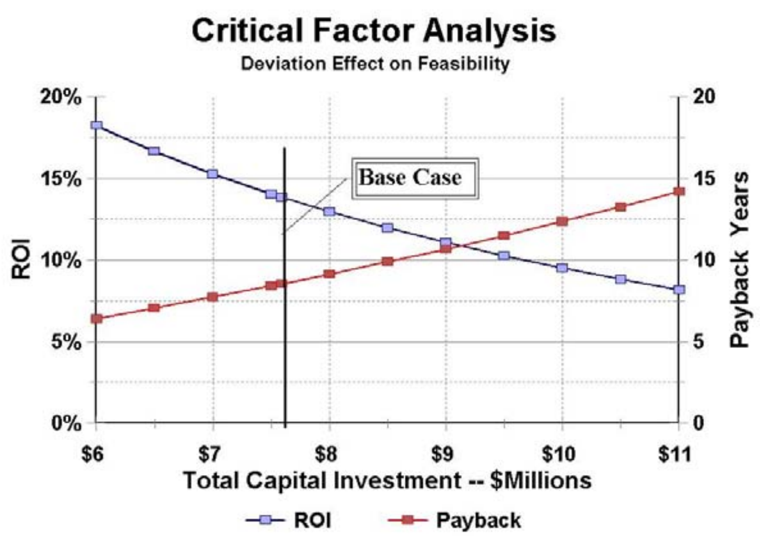
Exhibit 16 – Critical Factor Analysis, Total Capital Investment

Critical Factor Analysis

Factor -- **Total Capital Investment**

Description -- Total investment in the project.

Value	ROI	Payback	Notes
$6.00	18.3%	6.41 Yrs	
$6.50	16.7%	7.06 Yrs	
$7.00	15.3%	7.73 Yrs	
$7.50	14.1%	8.43 Yrs	
$7.59	13.8%	8.56 Yrs	Base
$8.00	13.0%	9.15 Yrs	
$8.50	12.0%	9.90 Yrs	
$9.00	11.1%	10.69 Yrs	
$9.50	10.3%	11.51 Yrs	
$10.00	9.5%	12.36 Yrs	
$10.50	8.8%	13.26 Yrs	
$11.00	8.2%	14.20 Yrs	



Exhibits 13 through 18 illustrate sensitivity analysis of economic factors on the feasibility of the overall project. The Macro-Sensitivity analysis of Exhibit 13 has been explained previously and is fairly self-explanatory. Micro-sensitivity analysis works to isolate the effect of each individual factor on the total project outcome. That effect can be shown in a number of ways, by calculating the result of a specified change in its value on annual income, capital investment and ROI (Exhibit 14) or by calculating the value of the factor necessary in order to reach a specified goal (Exhibit 15). Using the micro-sensitivity calculated values, and a third alternative as illustrated in Appendix Exhibit C-9, project feasibility can be "stressed" in order to identify economic factors that are critical to the financial success of the project. The sensitivity analysis capabilities of the computer model can be used to evaluate any business case scenario under a wide range of economic conditions.

Exhibit 17 – Critical Factor Analysis, Organic Residuals Price

Critical Factor Analysis

Factor -- **Organic Residuals Value -- $/Ton**

Description -- Average selling price for the organic residuals, bulk FOB the site.

Value	ROI	Payback	Notes
$0.00	0.6%		
$5.00	4.6%	23.17 Yrs	
$5.59	**5.0%**	21.61 Yrs	
$10.00	7.9%	14.59 Yrs	
$13.32	**10.0%**	11.80 Yrs	
$15.00	11.0%	10.77 Yrs	
$20.00	13.8%	8.56 Yrs	**Base**
$22.10	**15.0%**	7.88 Yrs	
$25.00	16.6%	7.11 Yrs	
$30.00	19.2%	6.09 Yrs	
$31.58	**20.0%**	5.82 Yrs	
$35.00	21.8%	5.32 Yrs	

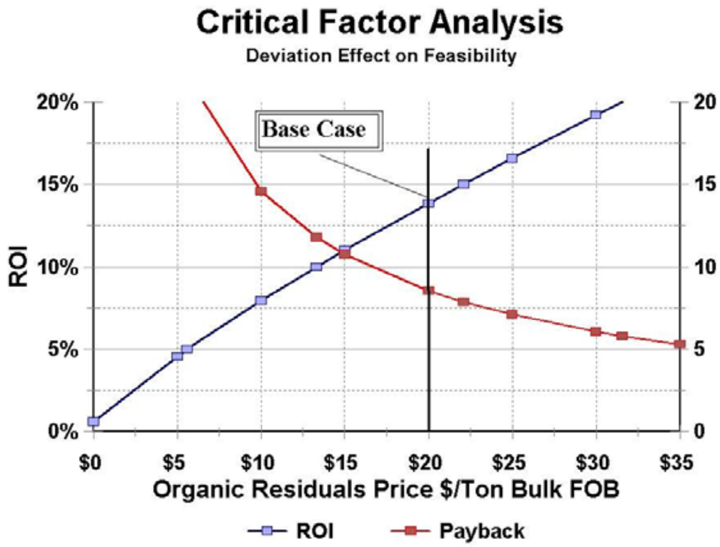


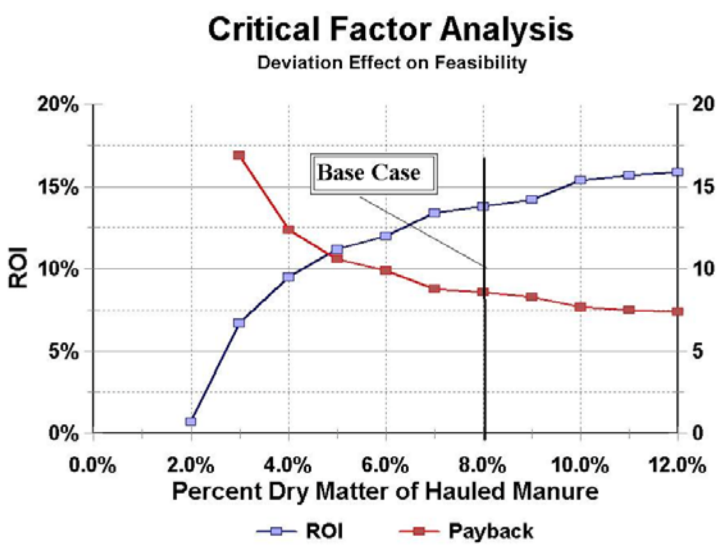
Exhibit 18 – Critical Factor Analysis, Dry Matter Content

Critical Factor Analysis

Factor -- **Percent Dry Matter of Hauled Manure**

Description -- Dry matter content of the material hauled to and entering the digester, inverse of moisture content.

Value	ROI	Payback	Notes
1%		Yrs	
2%	0.7%	Yrs	
3%	**6.7%**	16.90 Yrs	
4%	9.5%	12.40 Yrs	
5%	**11.2%**	10.60 Yrs	
6%	12.0%	9.90 Yrs	
7%	13.4%	8.80 Yrs	
8%	**13.8%**	8.60 Yrs	**Base**
9%	14.2%	8.30 Yrs	
10%	15.4%	7.70 Yrs	
11%	**15.7%**	7.50 Yrs	
12%	15.9%	7.40 Yrs	



The Critical Factor Analysis tables and charts of Exhibits 16-18 further illustrate the effect of an individual factor, varied through a range of potential actual values. Plotting of the ranged outcomes gives visual evidence of the sensitivity of the project outcome to deviations of a "critical factor". In the exhibits above and in Appendix C, factors critical to the success of the centralized digester/waste conversion project are examined and compared with the "base case" value. The range of values highlighted in yellow represents EnRRG's expectations of a 95% confidence interval – the actual outcome is 95% likely to fall within that range.

Exhibit 19 – Worksheet for Financial Structure Evaluation

Project Investment Analysis -- Ten Year Flows

(in $000's)

Dairy --- Thermophilic 13.84%

Project Cost	$7,592	Loan %	75%
Markup %	0%		
Management Fee %	20%		
Builder Margin	$0	Borrowed	$4,194
Project Total $	$7,592	Term Yrs	10.00
Credits	$2,000	Interest Rate	3.00%
		Annual Loan Pmt	$492
		Income Tax Rate	0%
		A/Tax ROE Target	25%
		Income -- Inflation Rate	2.00%
Return on Investor Equity		Expense -- Inflation rate	3.00%
B/Tax ROE	33.8%	Accelerated Writeoff	No
A/Tax ROE	33.8%	Depreciation Yrs	10

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10 Year Total	20 Year Total
Income													
Electric Offset		$364	$371	$378	$386	$393	$401	$409	$418	$426	$434	$3,980	$8,832
Gas Offset		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Income		$1,658	$1,691	$1,725	$1,759	$1,794	$1,830	$1,867	$1,904	$1,942	$1,981	$18,153	$40,280
Total		$2,021	$2,062	$2,103	$2,145	$2,188	$2,232	$2,276	$2,322	$2,368	$2,416	$22,133	$49,113
Expense													
Repair & Maint		$104	$107	$110	$113	$117	$120	$124	$128	$132	$136	$1,191	$2,791
Management Fee		$227	$230	$233	$236	$238	$241	$244	$247	$249	$252	$2,397	$5,065
Other Expense		$781	$805	$829	$854	$880	$906	$933	$961	$990	$1,020	$8,959	$20,998
Total		$1,113	$1,142	$1,172	$1,203	$1,235	$1,267	$1,301	$1,335	$1,371	$1,407	$12,546	$28,854
Net Oper Revenue		$909	$920	$931	$942	$953	$964	$975	$986	$997	$1,008	$9,587	$20,259
Interest		$126	$115	$104	$92	$80	$68	$55	$42	$28	$14	$723	$723
Depreciation		$559	$559	$559	$559	$559	$559	$559	$559	$559	$559	$5,592	$5,592
Principal Payment		$366	$377	$388	$400	$412	$424	$437	$450	$463	$477	$4,194	$4,194
Taxable Income		$224	$246	$268	$291	$314	$338	$361	$385	$410	$435	$3,272	$13,944
B/Tax Cash Flow	($1,398)	$417	$428	$439	$450	$462	$473	$484	$495	$506	$517	$4,670	$15,342
Income Tax		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Economic analysis is transformed into financial analysis through the worksheet shown in Exhibit 19. This worksheet allows the inclusion of borrowing, taxes, depreciation, inflation of costs and revenues, and other factors in the calculation of return on equity (ROE). The worksheet would be used by a prospective investor to evaluate leveraging schemes, depreciation strategies, and other management and ownership alternatives. The evaluation of the LLC business structure shown in Exhibit 23 is an offshoot of this worksheet. The potential number of combinations of factors that can be evaluated with this worksheet are too numerous to attempt to illustrate in this report. The worksheet is available for use by any potential investor in the project.

VIII. Ownership and Financing

In considering the prospective ownership and financing alternatives for a centralized project, one must take into account the nature of the project benefits, the expected return on capital invested and the inherent financial risk of such an investment.

The centralized project, as evaluated, has multiple benefit income streams as well as non-revenue benefits. The various revenue streams accrue to different parties, and there is little, if any, conflict among the parties. The prospective return on investment and payback is high enough to attract investors to the project and the risk factors, while they do exist, are well hedged due to the lack of reliance on only one or two income streams. A shortfall in any one income stream may be compensated for by a positive deviation in another.

There are several prospective ownership structures for a centralized digester project. Some of the possible ownership alternatives are shown in Exhibit 20, along with some pros and cons for each structure.

Exhibit 20 – Potential Business Structures

Business Structure	Pros	Cons
1. Cooperative of Dairymen	Producer Orientation Availability of Funding	Producers do not favor Typical problems of Coops
2. Utility Company	Vested interest in Success Availability of Financing Monetized Incentives	High investment per MW Outside Normal Business
3. Governmental Entity	Access to Funding Grants Bonds	Compatibility with dairymen Bureaucracy Lack of "business approach"
4. Third Party Investor	Compatibility with dairymen Access to Funding Market for Organic Residuals Business Orientation	Self Interest At expense of others? Compatibility Environmental Attitude?
5. Dairymen and Utility Co	Compatibility Access to Funding	Business Structure Issues Self Interest At expense of others?
6. Dairymen and Third Party	Compatibility Access to Funding	Business Structure Issues Self Interest At expense of others?
7. Other Investment Group	Depends	Depends

An ideal ownership structure for the centralized project would have two overriding characteristics:

- Access to adequate financial resources, and
- The ability and desire to work with the stakeholder parties in a mutually beneficial manner.

The dairymen do not favor a cooperative business organization even though, over the years, cooperatives have played a major role in agriculture. Cooperatives have often been considered an organization of last resort (rather than of choice) among people in rural areas, filling a need not adequately served by other business. A co-op organization could be successful if there was not another, better, alternative and if the members were dedicated to making it work. Without dedicated effort by its members a cooperative will not be successful.

Since utility companies benefit from the power produced and from the environmental benefits, ownership of this project by a utility company would seem a reasonable alternative. The investment could be justified both by return on investment prospects and by the desire to fulfill environmental objectives. The project would have incremental stockholder and public relations value. The small amount of power produced by the digester project and the fact that the project is so unique compared with a utility's mainline business leads to the concern of whether the project would receive adequate support and oversight necessary for it to attain full potential.

Ownership by a governmental entity has advantages and disadvantages. On the positive side is the access to funding, either as a tax-supported entity or through revenue bonds. There would be a strong incentive to make the project successful due to its wide-ranging public benefits and its high-profile status among environmental protection projects. A possible tendency to politicize such a project and not applying a business-based approach is a major concern, as is the inherent adversarial relationship of the affected dairymen with county bureaucracy.

Positive aspects of public ownership and private business practices could be blended through diligent implementation of a Port Authority. A Port Authority could have access to public funding and operate in a businesslike fashion by contracting for operation and management services. It could contract with the dairymen in such a way that they could share in the success of the project.

Ownership by a third-party investor is a viable alternative if the investor (individual, organization or company) is adequately financed and has a business philosophy that is compatible with the other project stakeholders. The goal of any non-governmental investor will be to profit on its investment. This project offers an investor such an opportunity. It would not be beneficial to the project or the other stakeholders if an investor were determined to maximize returns to the detriment of the other parties. Especially appropriate would be an investor whose primary interest is with the organic residuals, since residuals represent a major portion on the project income and they must be adequately utilized or marketed in order to achieve full value.

The alternative of combined ownership can have certain advantages if the parties are compatible and if they can maintain their respective interests in the company organization. A combined ownership will not work if one of the parties dominates, in a detrimental manner, the other owners.

There are advantages for having an ownership structure that includes the affected dairymen. They have so much at stake with this project and are such an important part of the formula for success that they should have a voice in the operation of the business and a stake in its financial success. However, they have made it abundantly clear that, with the current low prices for milk, they have no capacity to invest in such a project.

One way they could establish an ownership position without investing cash is through the EQIP program (Environmental Quality Incentive Program) of the Farm Bill. The EQIP program provides cost-share money for environmental practices and programs. Sixty percent of EQIP funds are allocated for livestock waste management projects. Many of the King County milk producers are currently using EQIP funds for various activities on their farms, such as lagoon construction or for solid separators. Preliminary indications are that a collective project such as this could qualify for EQIP cost-share funding.

Another part of the farm bill which could be a source of funding for this project is Section 1240H – "Innovative Grants – to stimulate innovative approaches . . .." This project, because of its innovative approach to nutrient management on a regional basis, and by its use of membrane technology to purify digester effluent could easily meet the requirements for such grants. Grants of this type could be included in the capital structure as equity in the name of the dairymen, thus earning them an ownership interest in the project without the need for cash.

Another way to provide project financing is through a process of monetizing the environmental incentives, whereby the income stream representing the incentives (carbon credits, PTC and green tags) is brought to current value with a one-time lump payment. Seattle City Light has expressed a willingness to consider monetizing up to one-half of the carbon credits resulting from a centralized project.

Exhibit 21 – Monetized Incentives

Monetizing the Incentives to Fund the Project

Incentive	Annual Units		Yrs	Lifetime Units	Unit Value	Annual Value $000	Lifetime Total Value $000	Discount Rate	Discounted Value $000
Partial Carbon Credits	19,288	MT	20	385,760	$5.00	$96	$1,929	2.00%	$1,577
Bal. Carbon Credits	19,288	MT	20	385,760	$5.00	$96	$1,929	2.00%	$1,577
PTC	10,386	MWh	10	103,860	$18.00	$187	$1,869	5.00%	$1,444
Subtotal						$380	$5,727		
Green Tags	10,386	MWh	20	207,720	$20.00	$208	$4,154	5.00%	$2,589
BPA's "Renewable"	10,386	MWh	20	207,720	$0.00	$0	$0	5.00%	$0
Subtotal					$20.00	$208	$4,154		
Total						$588	$9,881		$7,186

Exhibit 21 illustrates the concept of monetized incentives and approximates the value on those incentives. It shows that, if totally monetized, the incentives could essentially fund the entire project. Some portion of monetized incentives may be used to fund the project, but not likely in its entirety. Other financing options must be considered. Other, more typical sources for funding this project include: 1) equity capital, 2) commercial loans, and 3) revenue bonds.

Exhibit 22 -- Project Financing by Business Structure

Sources of Project Financing

Ownership Options and Funding Sources

	Equity Capital	Revenue Bonds	Grants	EQIP – Farm Program	Monetized Incentives	Commercial Loans
Cooperative of Dairymen	x		x	x		x

Utility Company	x	x	x		x	x
Governmental Entity		x	x			
Third Party Investor	x	x	x		x	x
Dairymen and Utility	x	x	x	x	x	x
Dairymen and Third Party	x	x	x	x	x	x
Other investment Group	x		x		x	x

Exhibit 22 summarizes the relationship of ownership structure with sources of funding which might be associated with that ownership. The last exhibit on this topic, Exhibit 23, illustrates a business structured as an LLC where the dairymen, as a group, hold a 50% ownership interest. The dairymen's combined ownership interest is reduced to a "per cow" basis so project revenues can be compared with the "user fees" which are a component of project income. Of particular interest to the dairymen is the fact that earnings, which flow directly to the LLC's ownership interests, more than offset the user fee that they have paid to participate in the project.

Exhibit 23 – LLC Business Structure for Dairymen Participation

Evaluation of LLC Earnings and Distributions

Dairy --- Thermophilic 13.84%

	Year 1	Year 5	Year 10	Year 15	Totals 10 Yr	Totals 20 Yr
Total ($000)						
Net Oper Income	$909	$953	$1,008	$1,062	$12,546	$28,854
Debt Service						
Interest	$126	$80	$14	$0	$723	$723
Principal	$366	$412	$477	$0	$4,194	$4,194
Depr	$559	$559	$559	$0	$5,592	$5,592
Tax	$0	$0	$0	$0	$0	$0
Cash Flow	$417	$462	$517	$1,062	$4,670	$15,342
Taxable to Partners	$224	$314	$435	$1,062	$3,272	$13,944
Producer Returns per Cow						
Net Oper Income	$75	$78	$83	$87	$1,033	$2,375
Debt Service						
Interest	$10	$7	$1	$0	$59	$59
Principal	$30	$34	$39	$0	$345	$345
Depr	$46	$46	$46	$0	$460	$460
Tax	$0	$0	$0	$0	$0	$0
Cash Flow	$34	$38	$43	$87	$384	$1,263
Taxable to Partners	$18	$26	$36	$87	$269	$1,148
Use Fee Paid	$40	$40	$40	$40	$400	$800
Net Taxable	($22)	($14)	($4)	$47	($131)	$348

Percent Ownership by Producers 50%

Summary of Findings and Conclusions

Following is a summary of the findings and conclusions of Environmental Resource Recovery Group, LLC in its assessment of the feasibility of "**Anaerobic Digesters for King County Dairies**".

A. The Parties

There are three distinct groups, which comprise the "interested parties" for this study – Dairymen of King County, Utility Companies and The Public. Each group has its own unique needs and expectations from a digester project, and each has a different set of potential contributions for such a project.

Dairymen – For the dairymen, management of the manure from their cow herds is a major cost factor and an impediment to their continued operation in King County. Mandated requirements for land application of nutrients in an approved agronomic manner severely restrict their ability to continue operation in the county. The small land base for nutrient application makes it difficult and costly to comply with current regulations, and the regulations will get even more restrictive in the future. If they are to stay in business, they must obtain some relief from the burden. Currently, the most practical alternative is to move their operations to another region where nutrients can be land-applied more readily in an approved and less costly manner. Generally speaking, the dairymen of the Enumclaw Plateau do not want to move away. They are mostly second or third generation producers who have strong ties to the region.

Compounding the problem is the current extremely low price for milk. The entire dairy industry is under severe financial strain. Any digester project must be accomplished with no out-of-pocked contribution from the dairymen group, either for capital investment or operating expenses, net of cost savings.

Utilities – Seattle City Light and Puget Sound Energy have interest in the potential benefits of environmental incentives resulting from a digester project. Each has been challenged to develop renewable energy and environmentally friendly alternatives in their business plans. The quantity of renewable energy produced from a digester project, even a centralized one, is quite small relative to the total energy load, but it is very environmentally friendly. Energy produced from waste is much more "green" than energy produced from wind, for example. Digester-derived electricity converts an environmental liability into an asset, while wind energy starts with an environmentally neutral raw material, the wind, and produces an asset. Therefore, the renewable energy produced from a centralized digester project should command a higher premium than from other sources. At a minimum, the Green Tags resulting from such a project should be easier to sell to power customers due the ability to identify the tags with a particular project, and the nature of the project.

The greenhouse gas potential of methane is generally estimated at 20 to 24 times that of carbon dioxide. A ton of methane contained, rather than emitted, has the value of 20 to 24 tons of carbon dioxide. Methane is currently emitted from anaerobic lagoons and from land application of animal manure in the county. An anaerobic digester project that captures methane, prevents its emission into the atmosphere, and converts it to energy will generate a significant quantity of greenhouse gas remediation credits (carbon credits) that are of value to Seattle City Light in meeting its goals. Alternatively, there is a developing world market for carbon credits in response to mandates of the Kyoto Treaty. Even though the United States is not a party to the Kyoto Treaty, credits produced in the U.S. can be utilized by companies in other countries to meet their quotas.

The public – Public interest is represented in this study by King County, Bonneville Environmental Foundation, King Conservation District and Washington State University. In general, the goal of the public sector is to carry out the wishes of the citizenry. In recent years, the public has expressed an increasing interest in preventing degradation of the environment and preserving it for future generations. More recently, the role of renewable energy in environmental protection has gained increased prominence. Public interest in a digester project for King County is represented by a need to maintain balanced economic activity while attaining beneficial environmental outcomes. A digester/waste conversion project must balance the multiple and conflicting interests of the public to attain the needed growth in economic activity while meeting environmental needs.

B. Geographic and Management Factors

Certain conditions of the Enumclaw Plateau milk production area are conducive to a successful centralized digester/waste conversion project. These factors can be categorized as: 1) geographic, and 2) dairy management practices.

There are approximately 30 dairies located in the Enumclaw Plateau area, with a combined total of about 9,000 milking cows. The land area of the plateau is about five miles by seven miles. The concentrated number of dairies in a relatively small land area reduces the potential cost of transporting manures to a central site and permits consideration of the centralized digester alternative. Inbound transportation cost of wastes to a central site is a major cost item for the project.

The small geographic area accentuates the difficulty in meeting nutrient management mandates. With such a limited amount of land available for fertilizer application, most dairymen are forced to apply wastes on the land of neighbors. In some cases they must haul it over a significant distance and at considerable cost, just to dispose of it. Nutrient management constraints are destined to become even more restrictive in the future, with the impact of either preventing dairymen from expanding their herds to be more competitive, or forcing them to either quit dairying or move their operation to another region.

Another geographic consideration is the development of homes in the region. Even though farmland may be protected by the Farmland Preservation Program, as land is taken for residential development fewer acres are available for land application of wastes. As the number of non-farm proper owners increases, the potential for odor-based conflicts will multiply.

EnRRG found the current waste handling practices of the dairymen to be conducive to a centralized digester project. The dairymen of the Plateau do not utilize flushing of barns and holding areas, a management practice common in many dairies. They all scrape to a central point then pump to their lagoon. Some use solids separators. Flushing adds water to the waste stream which would have to be transported to the central site and would increase the size and operating cost of the digester. Ideally, the waste going to a central digester should be in the range of 8-10 percent solids – thin enough to pump but concentrated enough to minimize the transport cost and digester sizing. With attention to managing parlor wash water and preventing rainwater from mixing with the scraped manure, the current practices are nearly ideal for a centralized digester project.

Producer attitudes are highly favorable for a centralized digester. They recognize that they must overcome the constraints of manure management if they are to stay in business in the Enumclaw Plateau area. They want to do so. Constraints on their participation in a central project include: 1) they must be treated fairly, as an equal partner in any project, 2) they cannot be burdened with increased operating costs compared with current practices (preferably save costs), and 3) they have no capital to contribute directly to a project due to severely low milk prices. These constraints are significant, but EnRRG believes they can be met.

C. Single-Farm or Centralized

EnRRG found little justification for a single-farm digester project in the Enumclaw region. Technically, a small-scale digester will work as intended. But, application of membrane technology in conjunction with a digester is what, ultimately, allows a centralized project to meet the needs of the dairymen, allowing the economical movement of nutrients from the region. Economics of scale do not allow the use of membrane technology in a single-farm digester. Utility companies would not be able to obtain value for the environmental incentives of a singly-farm digester due to the small scale. Financial returns for a single-farm digester are meager. EnRRG found little enthusiasm among the parties of the study for pursuing the single farm alternative.

D. Conclusions

1. An on-farm digester serving one farm, or a small cluster of farms, is not considered to meet the tests of feasibility in King County, due to the low prospective returns on investment and the inability to satisfy the needs of the affected parties. In particular, the single farm digester will not reduce the amount on nutrients which the dairymen are required to utilize in their nutrient management plans, and would therefore not aid them in their most pressing need.

2. A centralized digester combined with membrane technology does meet the tests for feasibility in the county. Such a project shows a very acceptable financial return and meets the identified needs of all parties to the study – dairymen, utilities and the public.

3. A centralized project combining anaerobic digestion and membrane technology would be a high-profile and innovative, yet technically sound, approach to reducing environmental liability while producing renewable energy and greenhouse gas mitigation. EnRRG knows of no other project which combines the two technologies in this way,

4. A centralized project as described would be considered "innovative and high-profile" from several aspects:

    a. Management of animal manure nutrients on a regionalized basis, removing much of the burden from the individual dairyman. The effects should be a lower cost and more consistent pattern of nutrient management compliance compared with the alternative of each dairyman developing, implementing and keeping records on his individual nutrient management plan.

    b. The use of membrane technology to both improve the effectiveness of anaerobic digestion in reducing environmental risks, and allow the management of nutrients by concentrating them into an economically transportable form. Using UFRO (Ultrafiltration/Reverse Osmosis) technology can produce re-use or discharge quality water as an output, enhancing the value of the project for environmental security. Concentrating the nutrients in a small water fraction allows the economical transport of nutrients from the region into areas where they can be better utilized and can be sold for their economic value. Advances in membrane technology in recent years have brought operating costs down to the point where it can be used for this application. The unique needs of the dairymen of the Enumclaw Plateau dictate the application of UFRO for this project. It would not be used if there were a more cost effective use for the digester effluent liquid, such as irrigation directly onto adjoining farmland.

    c. Cooperative efforts of dissimilar parties, with dissimilar goals, in a project that serves all parties well without negative effects for any. Rarely does such an opportunity present itself. This project could be the model which to be applied in other locales.

5. The ability to fund such a project is enhanced by its favorable return on investment and financial payback, its broad range of income sources, and its diversity of participating parties. Each of the affected parties has the ability to attract funds from direct investment and from various grants sources. Any grant funds, which can be attracted, will enhance the project, but the project can be viable without subsidization by such grants.

E. Critical Issues

There are certain issues, which should be given due consideration before going forward with a digester project.

1. Production Tax Credit (PTC) – The production tax credit for renewable electricity production that is included in the economic analysis (all cases) is not currently in effect for projects such as this one. The Energy Bill of 2002 would have extended the life of the PTC and allowed its application to projects involving manure from all animals. Current legislation specifically includes only poultry litter for the credit. The 2002 bills passed by both houses of Congress but never made it to conference before the end of the session so were not enacted into law. The 2003 bills are currently under consideration. It is very likely the PTC will be extended. It is the basis for all development of wind power. It is also likely the new bill will extend the PTC to power produced by all biomass. At this time, however, the PTC does not apply to a digester project originating from dairy manure. The PTC is currently 1.8 cents per kilowatt-hour for a period of 10 years, inflated annually by the consumer price index. Since it is a tax credit, its value is greater than 1.8 cents in pre-tax income for a tax-paying entity. If the PTC were not applicable to the digester projects evaluated in this study, the value of the environmental credits would be reduced by 1.8 cents per kilowatt-hour, and the return on investment would be reduced accordingly. (See the Critical Factor Analysis tables of Appendix C)

2. Value of Organic Residuals – The sale of solid organic residuals constitutes over one-third of the total revenues of the project. These residuals will not sell themselves – they must be marketed. Competitive products with significantly lower intrinsic value (compost and peat moss) are currently being sold, in quantity, at a price higher than that being used as an assumed value for the residuals in the financial analysis. Even so, without a commensurate marketing effort to sell the residuals, the expected value will not be attained. Conversely, since the product is priced at a relatively low value, there is significant upside potential for this income component, with a correspondingly improved project payback.

3. Solids content of Transported Wastes -- It is imperative that rainwater is prevented from mixing with the collected manure at the dairy farms. The economic analysis is based on 8 percent solids, on average, in the transported wastes. The Critical Factor Analysis table clearly shows the effect that added water in the waste stream has on the economic viability of the project. If the solids content drops below 4 percent, the economic feasibility of the entire project is threatened. Added water to the waste stream affects the economics of the project by: 1) increasing the volume (and cost) of material transported to the central site, 2) increasing the required volume (and capital cost) of the digester vessels, 3) increasing the cost of membrane separation of the digester effluent, and 4) increasing the heat component necessary to bring the incoming material up to digester temperature. If the project is implemented, great effort must be put forth at each individual dairy to minimize the extra water (rainwater and parlor wash water) that mixes with the manure.

4. While the involvement of three dissimilar parties in a mutually beneficial project may be considered positive and innovative, it must be implemented properly in order to achieve the desired results. In implementing such a project, all parties must be treated honestly and fairly, as equals in the final project business plan. Efforts to maximize value for one party cannot be made at the expense of another. The concept sounds simple enough, but there will be conflicts that arise which must be addressed successfully, at the risk of the success of the overall project. This concern bears upon the ownership structure for the project, since some potential ownership structures are more prone than others to a conflict of this nature.