

# Dairy Manure Anaerobic Digester Feasibility Study Report

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## Executive Summary

In September of 2009 discussions were started between Noble Dairy, EC Oregon and Northwest Dairy Association regarding the development of an anaerobic digester. A feasibility study was initiated to determine if digestion is a technically and financially viable option for converting dairy manure to energy at the farm. To that end, EC Oregon assessed dairy manure degradability, reviewed relevant literature, identified locally available additional feedstocks, researched technology options, estimated energy/co-product outputs and system costs and produced pro forma financial analysis. The study was funded by the Energy Trust of Oregon and a Community Renewable Energy Feasibility grant from the Oregon Department of Energy.

Anaerobic digestion of dairy manure is proven technology, immediately available for commercial applications from an ample number of qualified vendors with flexible designs. For the most part, on farm practices at Noble Dairy are technically compatible with anaerobic digestion. However, the seasonal pasturing required per Organic practices and flush manure collection system both reduce the amount of recoverable manure and hence methane production.

EC Oregon has not, to date, discovered a realistic combination of capital expenditure, operations and maintenance costs, conversion efficiencies, product price points and incentives that allows a manure-only digester to be profitable at a level required to attract investors. The widely preferred approach in Germany and Austria (the world leaders in digestion) is to use “complete mix” digester technology operating at mesophilic temperatures while utilizing multiple co-digestion feedstocks. The ability to accept a wide variety of co-digestion feedstocks provides complete mix biogas plants a measure of operational security over conversion technologies. Based on this fact in conjunction with recent vendor responses, it is recommended that Noble Dairy consider a co-digestion scenario with a complete mix digester and a CHP in which electricity is sold under a “sell all” power purchase agreement.

A scenario is proposed that offers feedstock flexibility, consistent methane production, pathogen reduction, nutrient management, high quality fiber bedding and odor control. The potential for diversified revenue and/or avoided costs to the dairy could help mitigate recent fluctuations of milk prices and energy and feed costs. The proposed co-digestion scenario using straw, fats/oils/greases and food processor waste produces biomethane at a rate of approximately nine times that of a manure only approach. However, financial modeling using conservative, yet realistic assumptions, results in returns that are likely not adequate to attract investment interest. The proposed biogas plant requires an initial capital expenditure of \$5.7M, has a return on investment of 21+ years and 1.9% internal rate of return.

Sensitivity analysis identified critical variables; the following methods are recommended to improve overall financial viability:

- Identify measures to mitigate straw acquisition costs
- Secure sources of food processor waste, potentially garnering tipping fees
- Incorporate straw as bedding to increase fiber revenues
- Negotiate a power purchase agreement exclusive of published utility rate schedules
- Develop markets and identify off-take agreements for fiber and fertilizer co-products
- Identify an on-farm use for CHP waste heat, potentially adsorption chilling of milk

# 1. Introduction – Project Details

## 1.1 REPORT ORGANIZATION

Thorough assessment of all technical and financial aspects of anaerobic digestion feasibility is a complex undertaking. In an effort to provide clear and concise results, the body of the report has been distilled down to the essentials. However, supporting detail has been placed in appendices, arranged by chapter. This supplementary information is not required reading, but is made available for interested parties.

## 1.2 PROJECT ORIGIN/PARAMETERS

In September 2009 discussions began between Jerry Noble of Noble Dairy, EC Oregon and Northwest Dairy Association regarding the feasibility of an anaerobic digester. A study feasibility study was initiated to determine if AD is a technically and financially viable option for converting dairy manure to energy at the Noble Dairy farm in Grants Pass, Oregon. To that end, EC Oregon assessed dairy manure degradability, reviewed relevant literature, identified locally available additional feedstocks, researched technology options, estimated energy and co-product outputs, and system costs and produced pro forma financial analysis. The feasibility effort was fully funded, in part by a Community Renewable Energy Fund (CREF) grant awarded to EC Oregon by the Oregon Department of Energy; matching funds were provided by the Energy Trust of Oregon.

## 1.3 EXISTING OPERATIONS

Noble Dairy is an Organic dairy that has both Holstein and Brown Swiss cows. The dairy receives 70% of its bedding as sawdust for free from local mills; the remainder of the bedding is variable and costs \$800 per month. All barns are freestall barns. Most barns collect manure by flushing, but the older barns with improper slopes use additional scrape collection. Flush water is collected in a 55,000 gallon receiver tank. After separation the liquid fraction enters a 100,000 gallon settling pond before proceeding to a 120,000 gallon daily flushing pond. Every 3 to 5 days the flush pond contents are pumped to a 3,000,000 gallon lagoon and replaced with fresh water. The main ranch has 125 acres in silage and another 210 acres of pasture land for grazing. Another 100 acres are available at two satellite ranches less than 3 miles away. The current value for manure is ~ \$7/ton as liquid fertilizer and ~ \$10/ton as fiber.

**Table 1 Current herd distribution**

Milkers	Dry Cows	Heifers	Calves	Total Head
640	80	350	50	1120

## 1.4 ISSUES OF CONCERN

While dairy manure is being used as anaerobic digester feedstock in various scenarios throughout the world, it is by no means standard business practice; consideration must be given to the type and quality of livestock feed, rearing and handling practices, and potential antibiotic/hormone treatments. Numerous dairy manure anaerobic digesters exist in the U.S. – of the 135 farm-scale digesters reported to be operating in this country, 107 are located at dairy farms. These systems do not lend themselves to cookie-cutter application. The operational parameters of the dairy will determine the appropriate conversion technology, digester loading rate, biogas production and energy utilization specifics. Co-digestion substrate availability, heat recovery options and utility interconnection scenarios must also be identified for each project. Therefore, each digester system must be designed to meet the specifics of the site and end product(s) desired.

Dairy manure is not a particularly energy dense AD feedstock; returns on dairy manure digesters are often marginal at best. EC Oregon has not, to date, been able to identify a realistic combination of capital expenditure, operations and maintenance costs, conversion efficiencies, product price points and incentives that allows a manure-only digester to be profitable at a level required to attract investors. Since most Oregon dairy farms typically do not have the fiscal means to secure financing without third-party investment (even for low cost digester options), this report assumes co-digestion of energy dense substrates to be a prerequisite to successful development.

Specifics of manure management and other farm practices could result in technically and financially challenging digester projects. Case-specific issues for this study include:

- Noble Dairy collects manure by flush collection. Any efficiency gained in manure collection with a flush system is outweighed by the significantly larger volume of cold water that requires heating to at least mesophilic temperatures (90-100°F) for efficient methane yields. Additionally, thickening flushed manure to reduce the volume to be treated will result in some loss of volatile solids (VS) which, in turn, reduces methane production.
- Noble Dairy uses sawdust for a majority of their bedding. Sawdust has a high lignin content and low pH, making it less than desirable for digestion. The high lignin content will limit methane yields and the low pH of wood products could disrupt biological stability. Wood based beddings are incompatible with some digester designs due to concerns with clogging and mat formation.
- Nobel Dairy follows the USDA's National Organic Program that dictates cows must be pastured at least 120 days per year, among other things. Noble Dairy attempts to pasture in excess of the requirement (150 days) which further reduces the amount of seasonally collectable manure, by as much as an estimated 40% annually.

## **1.5 BENEFITS**

Anaerobic digestion, when done properly, will generate diversified revenue while mitigating odor issues and providing nutrient management flexibility. This technology has the potential to solve waste handling challenges while producing renewable gas, electricity, heat and fertilizer – a win-win for dairy farms, their neighbors and their utility providers.

Additional AD benefits include reduced lagoon loading, composting labor, and farm management of composted manure solids while providing potential bedding and non-clogging liquid fertilizer. Manure digester systems also have significant emission reduction benefits; methane is 21 times more potent than carbon dioxide as a greenhouse gas.

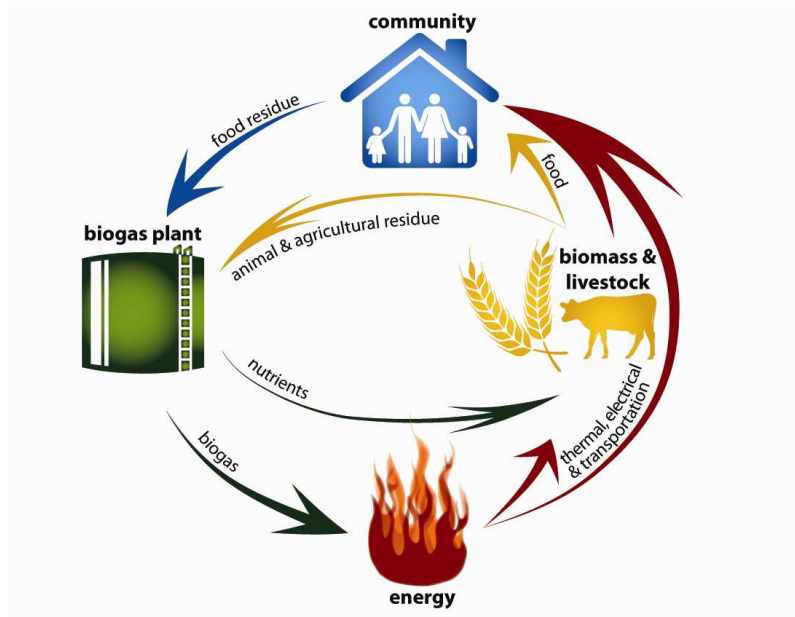
## **1.6 PROJECT GOALS & POTENTIAL SOLUTIONS**

Noble Dairy is interested in developing a biogas plant that utilizes the farm's manure provided digester management does not negatively impact current dairy practices. The proximity to agricultural land and two urban centers (Grants Pass and Medford, Oregon) present numerous potentially suitable organic substrates for co-digestion. Potential co-generation of electricity and heat would also create an opportunity for the dairy to offset current propane use for water and space heating.

Dairy farms with more than 500 head are often quoted as being favorable for AD technology. However, at this level it is not clear if farms are actually generating revenue by installing an anaerobic digester or merely reducing waste management and energy costs. Noble Dairy is slightly above the suggested minimum size for successful AD development. Nevertheless, a feasibility study is necessary to optimize the farm's needs with an appropriate technology. Noble Dairy has specific concerns about odor control, a problem solved with all types of digesters – if properly designed and managed. This feasibility study determines the most appropriate technology that provides odor control while attempting to maximize the financial benefits of producing renewable energy without sacrificing nutrient management and environmental compliance.

## 2. Anaerobic Digestion Technology

Anaerobic digestion (AD) is the controlled microbial decomposition of organic matter in the absence of oxygen. Biogas (mainly methane and carbon dioxide) is an end-product of AD. Traditionally, the primary use of AD has been to sanitize waste materials and reduce biological oxygen demand (BOD) and chemical oxygen demand (COD) associated with livestock operations, industrial facilities or municipal waste water treatment plants. The bio-methane in biogas is a renewable natural gas replacement. Anaerobic digestion is widespread throughout the European Union (EU) and Asia, but is under represented in the United States primarily due to historically low energy costs. As the interest in utilization of bio-methane as a renewable fuel has increased, more research and pilot projects have begun to assess various waste streams, known as feedstocks, specifically for energy production. Digester systems (known as biogas plants in the EU) are applicable to a wide range of situations. Synergy is most realized at facilities that have access to sizable organic feedstock at little to no cost, require electricity and heat that can be provided by a biogas-powered combined heat and power unit (CHP) or through the direct use of biogas (such as boilers), and can utilize or market the digester effluent as compost and liquid fertilizer. The technology can be instrumental in providing renewable energy to industry and the agricultural community while closing the loop on the nutrient cycle.



**Figure 1 Schematic illustrating the sustainability of AD (EC Oregon, 2009)**

Digester technology has been developed with a multitude of different approaches. The feedstock can be mixed or unmixed. The vessel can be a pond or tank of varying sizes, shape, and orientation. Operating temperatures range from psychrophilic (ground temperature) to mesophilic (37 to 41 °C) to thermophilic (50 to 52 °C). The amount of total solids (TS) processed by different technologies can vary, as well as the hydraulic residence time (HRT) and solids residence time (SRT) which can be coupled or decoupled.

## 2.1 DIGESTER TYPES

General categories of AD technology for dairy manure include: traditional, high rate, and contact. Traditional digesters, which include anaerobic lagoons, plug flow and complete mix reactors (mesophilic or thermophilic), are the most commonly used digesters for dairy manure. Due to clogging issues and the limitations for processing only soluble fractions, digesters such as anaerobic filters, upflow anaerobic sludge blankets (UASB), anaerobic baffled reactors, various biofilm processes and fixed film packed bed reactors are not recommended for dairy manure systems. Certain modified UASB systems such as the Induced Blanket Reactor (IBR) are designed to handle feedstock with slightly higher solids content and may be applicable.

Traditional digesters are described in detail below. More information about high rate and contact type digesters is located in the appendices for this section.

### Anaerobic Lagoons

Anaerobic lagoons are essentially covered ponds which can be mixed or not mixed. Lagoons operate at a psychrophilic temperature which leads to seasonal production variability. They generally have poor bacteria to substrate contact; hence a very low processing rate (high HRT) and large footprint are required. Covered lagoons are a low capital investment for production of biogas, but tend to underperform other technologies for biogas production, electricity generation, and weed seed and pathogen reduction. Covered lagoons largely focus on odor control and emission reductions and therefore do not optimize biomethane production.

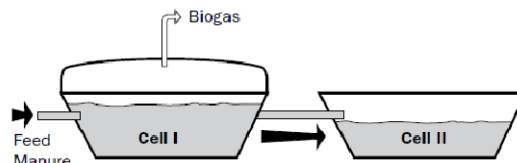


Figure 2 Anaerobic lagoon (Ogejo, 2007)

### Plug flow digesters

Plug flow digesters are linear (horizontal or vertical) shaped reactors - influent enters on one end and effluent exits on the other. They are typically not mixed; substrate moves through the reactor in a “slug” and  $HRT = SRT$ . Plug flow digesters have a narrow solids range to avoid stratification or obstruction. They have moderate capital and operational costs, and require periodic cleaning of the system which incurs downtime.

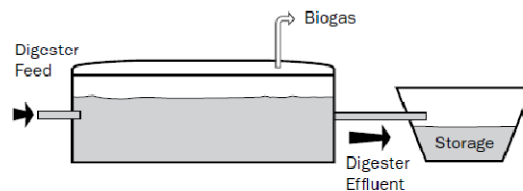


Figure 3 Plug flow digester (Ogejo, 2007)

These digesters were designed to handle feedstock at high percent solids as a simple push-through technique. As feedstock is added at one end, an equal proportion is removed from the other side. Although other designs exist, a typical design is a heated below grade rectangular tank covered with an air tight expandable membrane. With an expected HRT of 20-30 days, plug-flow digesters are typically designed to handle solids contents in the range of 11 to 13

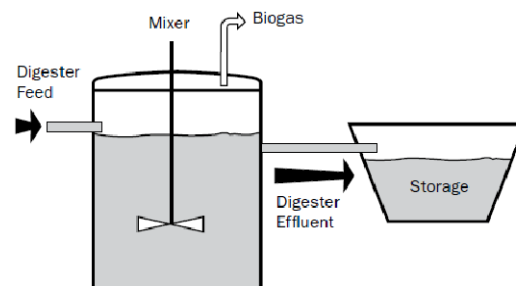
percent, however there are numerous case studies where dairy manure is being fed to a plug-flow digester at 7- 8% solids.

Limitations associated with plug-flow digesters include sands and silt settling out, stratification of dilute wastes, unsuitability for dilute milking wastes, and lower methane production. Modified versions of the plug-flow digester exist that try to either improve efficiency or recover bacterial biomass such as:

- U-shaped digester: has a shared wall containing the heating elements
- Re-injected liquid: liquid sucked out of the bottom of the digester and outflowing digester sludge are reintroduced to help pre-heat the sludge and maintain bacterial biomass.

### **Complete Mix or Continuous Stirred Tank Reactor**

Complete Mix or Continuous Stirred Tank Reactor (CSTR) is typically a concrete or metal cylinder with a low height to diameter ratio. They can operate at mesophilic or thermophilic temperatures; mixing can be mechanical, hydraulic or via gas injection. Complete mix can accommodate a wide range of solids and generally, HRT = SRT. Higher capital and operational costs are balanced against the stability of the system and reliability of energy production. Additionally, the CSTR accepts multiple co-digestion feedstocks which may allow for an additional source of revenue through increased methane production and tipping-fees.



**Figure 4 Complete mix digester (CSTR) (Ogejo, 2007)**

### **Induced Blanket Reactor (IBR)**

An induced blanket reactor is a modified version of the UASB digester designed for HRT of 5 to 8 days. With a sludge blanket maintained within the bioreactor, slow growing bacteria are retained in the tank which accelerates digestion of slurry. The technology consists of multiple above ground tanks with high height to diameter ratios, modular design allows for isolation and repair of failed tanks. Tanks are designed as flow through systems with influent entering at the bottom and effluent exiting through the top. Solids and slow growing bacteria are retained on a septum with a plugging control mechanism. Formation of a sludge blanket consisting primarily of bacteria occurs in the lower portion of the tank. As methane bubbles up, bacterial aggregates of methanogens float up to the septum, the septum separates the methanogens from the gas, bacteria return to the bottom of the tank and gas exits via the septum. Additional recirculation of the effluent helps retain any bacteria that got past the septum.

## 2.2 DIGESTER TECHNOLOGY ASSESSMENT

In the US, 94% of dairy farm based AD systems are plug flow, complete mix reactors or covered lagoon digesters. However, the relative distribution of these technologies does not necessarily reflect the needs of all dairy farms. Although economics are a key metric for some owners, other digesters are installed mainly to control odor and excess nutrient runoff. The two most often used technologies are plug-flow reactors and complete mix reactor digesters.

**Table 2 Distribution of current AD technology on US dairy farms (AgStar, 2009)**

Digester Type	Number of digesters operating on dairy farm (%)	Number of digesters on dairy farms with herds less than 1,250 head (%)
Covered Lagoon	10 (9%)	9 (17%)
Complete Mix	26 (24%)	8 (17%)
Fixed Film	1 (1%)	1 (2%)
Induced Blanket Reactor	2 (2%)	-
Plug-flow	65 (61%)	33 (61%)
Unknown	3 (3%)	2 (4%)
Total	107	53

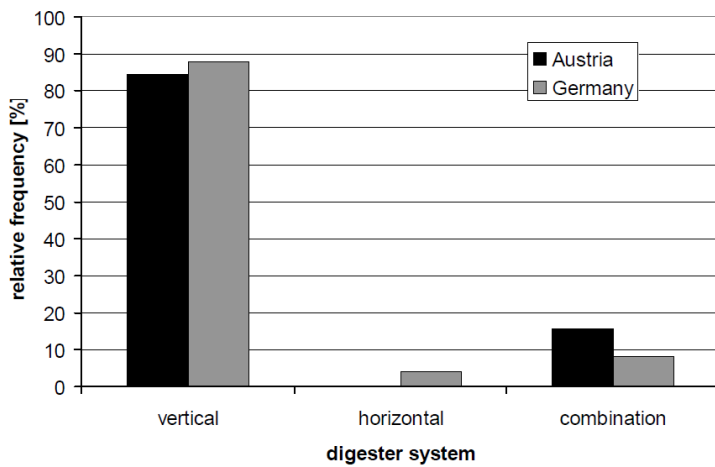
As mentioned earlier, energy output per capital investment is not the only selection criteria for anaerobic digester technology. A matrix is provided to compare the relative features of each design as reported by various vendors.

**Table 3 Suitable digester technology matrix (EC Oregon, 2009)**

	Covered Lagoon	Plug Flow	Complete Mix	IBR
Max allowable solids size	Fine	Coarse	Coarse	Coarse
Technology level	Low	Low	Medium	Medium
Operating Temperature	Psychrophilic	Mesophilic	Mesophilic or Thermophilic	Mesophilic
Co-digestion compatible	No	Limited	Yes	Limited
Solids separation prior to digestion	Recommended	Not Necessary	Not Necessary	Not Necessary
Footprint	Large	Small (if underground)	Medium	Small (modular)
OLR	Low	Medium	Medium	High
HRT	> 48 days	20 - 40 days	20 - 30 days	10 days
VS reduction <sup>(1)</sup>	35 - 45%	35 - 45%	35 - 45%	50-55%
Biogas yields	Low	High	High	High
Costs	Low	Medium	Medium	Medium
Suitable % solids	< 3	7 - 13%	3 - 12%	2 - 10%

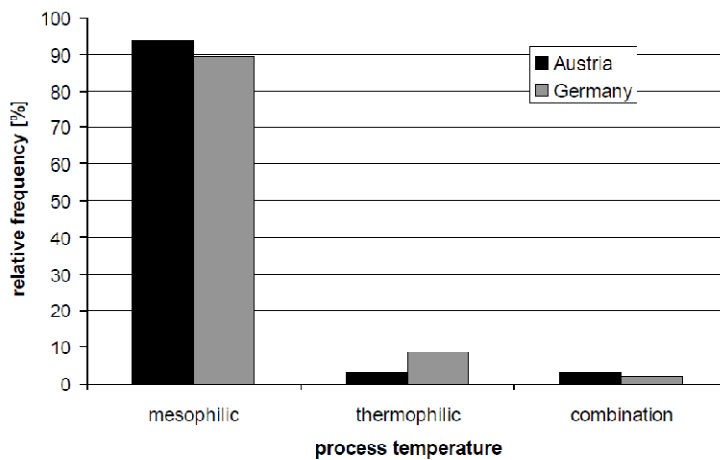
1. VS reduction of dairy cow manure.

Complete mix or continuously stirred reactor tank (CSTR) digesters represent a proven and effective technology for feedstock with a wide range of total solids. Complete mix systems run at a steady state with continuous flow of reactants and products; the feed assumes a uniform composition throughout the reactor and the exit stream has the same composition as in the tank. This homogenization ensures maximum contact between substrate and microbe, enhancing the digestion process and biogas quality. For this reason, complete mix (aka “vertical”) systems are widely preferred over plug flow (aka “horizontal”) systems in the EU.



**Figure 5** Frequency distribution of digester technologies for AD facilities built in Austria and Germany between 2003 and 2005. (Hopfner-Sixt, et al. 2005)

The preferred operating temperature range of new biogas facilities in the EU is mesophilic. The greater stability and lower parasitic heat load of mesophilic systems outweighs the decreased retention time and smaller footprint of thermophilic systems.



**Figure 6** Frequency distribution of operating temperatures for AD facilities built in Austria and Germany between 2003 and 2005. (Hopfner-Sixt, et al. 2005)

### 3. Feedstock Digestibility and Handling Assessment

The microbial community found in AD systems requires a relatively steady stream of feedstock on a daily basis. Underfeeding will result in reductions in microbial population and methane production; overfeeding can result in excessive by-product formation, increased toxicity and potential digester “crash”. Any changes in feeding regime quantity or type need to be incorporated gradually.

#### 3.1 DAIRY MANURE ANALYSIS

Survey information detailing waste stream availability and farm practices was gathered from Jerry Noble in early October 2009. Survey data, guidelines from Oregon’s Animal Waste Management Plan (AWMP), literature data and ongoing conversations with Jerry Noble provide the basis for the estimates in the feasibility study.

The amount of manure impacts multiple design and feasibility variables such as methane production, required vessel volume and biomass producer tax credit; the use of conservative estimates prevents presentation of an overly optimistic financial model. According to literature, manure output has been shown to be correlated to milk production, dry matter intake, pregnancy rates, month in milk and season, among other factors. Noble Dairy indicated current milk production is 60 lbs/day/cow. The AWMP indicates milk production of 60 lbs/day/cow corresponds to a manure output for milkers of 102 lbs/animal unit (AU)/day; dry cows and heifers are estimated to produce 57 lbs/AU/day; calves are estimated to produce 77 lbs/AU/day.

Since bedding invariably gets incorporated into the collected manure, this adds an additional tonnage of solids entering the reception pit. The quantity of bedding to be used is currently unknown, but is assumed to be close to 10 lbs of bedding/cow/day. This application rate approximates bedding at about 10% of manure produced – an amount used by a similar dairy operation in the Willamette Valley.

Estimates for manure production and bedding are provided based on these assumptions.

**Table 4 Quantity of dairy manure and bedding**

Total Head	Manure <sup>(1)</sup> (tpd)	Bedding (tpd)
1,120	54	5

1. Manure on as excreted basis regardless of manure collection.

#### 3.2 MANURE QUALITY ASSESSMENT

Methane yields of dairy manure are dependent on manure collection and handling methods. As long as manure is collected in a fresh state most of the methane potential will be recovered, however as manure ages the methane potential quickly decreases. Although it has been suggested that flushed and scraped methane recovery are essentially the same, tradeoffs exist between collection efficiency, digester volume, digester technology, parasitic heat load and odor control. If properly managed, both methods collect manure in a fresh state (i.e., no reduction in VS), but flush systems significantly increase the volume to be treated. The efficiency or convenience of a flush system is outweighed by the significantly larger volume of cold water that must be heated to at least mesophilic temperatures for efficient methane yields. The

commercially proven digester technologies are designed to optimally handle specific ranges of TS. This means flushed manure will need to be thickened to reduce the mass and increase solids content.

***Manure Quality at Noble Dairy*** - Although flush manure collection is a technically viable option for energy production, it does present challenges. Occupying digester volume with feedstock that has biomethane potential, instead of water, improves the financial outlook. Since dairy manure is typically excreted at 12-15% TS, converting to a scrape based collection allows manure collection to be directly compatible with complete mix and plug-flow.

A thickening process should be utilized with flush-based systems in order to raise the total solids content. In addition to the capital cost of the additional infrastructure, the use of a thickener has other implications. Separation of solids prior to digestion of volatile solids in the liquids lowers the methane yield of the manure by as much as 25%. More importantly, by removing the liquid from the flushed manure, the digester size could be reduced by as much as 50%. For this study, a simple weir design is assumed to thicken from 1.5% to 4.0% TS with an assumed loss of 15% VS.

In order to improve the manure quality at Noble Dairy and utilize all the manure VS, switching to a scrape collection method would be preferred over a thickener or using high concentrations of dry organic matter. Automated scrape based manure collection systems exist with similar efficiencies and conveniences to flush based collection systems. Electric, programmable alley scrapers are touted as labor saving devices that are safe for cows lingering in the alleys. A hinged scraper blade is pulled down the alley on a cable or chain by a geared low-horsepower motor; the blades retract for the return trip. Increased scraping frequency may contribute to cleaner barns. Manure management related incentives, such as the USDA's NRCS Environmental Quality Incentives Program (EQIP) can provide capital cost share. Since the switch to scrape is recommended for efficient digester operation and would be directly involved in collecting feedstock for renewable energy production, an automated scrape system may also qualify for Oregon's Business Energy Tax Credit (BETC).

### **3.3 CO-DIGESTION FEEDSTOCK NEAR GRANTS PASS, OREGON**

Any loss of methane potential due to thickening of flushed manure can be offset by importing other feedstocks. The ability to take in co-digestion substrates allows the owner to take advantage of the economy of scale principle while digesting higher energy feedstock. This in turn enhances the financial feasibility and profitability potential. Certain co-substrates can produce a disproportional increase in biogas production relative to the feed percentage.

An assessment of local co-digestion feedstock suggests the farm has access to sizable amounts of numerous co-digestion substrates. The dairy is located near two urban areas (Grants Pass and Medford). Costs to acquire these feedstocks will vary from moderate to free; in some cases tipping fees may provide a further revenue stream. Producers and collectors of biomass utilized in the production of renewable energy are eligible for state tax credits on a per ton basis – providing incentive over current end uses.

- Fats, oils and grease (FOG) in the form of local food processor waste and grease trap waste (GTW) are estimated to be available at the rate of 5.7 tpd.
- There is 1 large poultry operation (320,000 layers) with an estimated 6,000 tpy of poultry litter (manure and bedding).
- Based on population data, collectable municipal food waste (MFW) from multiple sources is estimated at 6 tpd.
- Crop residues, such as wheat straw, may be suitable for ensiling seasonally available food processor residue. Oregon's Southern Region has an annual amount of about 8,760 dry tons of wheat straw from Jackson, Josephine, Douglas, and Klamath counties.
- Based on active licenses as of October 2009, there are 5 large size (>\$20million in annual sales) food processing companies (e.g. fruits and vegetables) operating in close proximity to Noble Dairy.

Processors with relatively large residue streams include Sabroso, Associated Fruit Company, and Amy's Kitchen. Recent conversations with Sabroso reveal that for 6 months of the year (August to January) they have 8-10 tpd fruit processing residue available. Additional wastewater is available from Sabroso, but with low TS content will not make much sense to ship. Associated Fruit Company has 8.4-12 tpd of fruit waste available from the middle of August through the middle of January. Amy's Kitchen has shaker waste, onion peels, okara residue, and DAF Cake available at an average rate of 15 tpd for 6 months of the year (January to June). Okara whey from Amy's Kitchen has a low solids content which does not warrant long distance hauling.

The following small quantities of on farm sources of co-digestion feedstock could also be utilized:

- Silage liquor from the silage bunker.
- Wasted cow feed (silage and supplements).

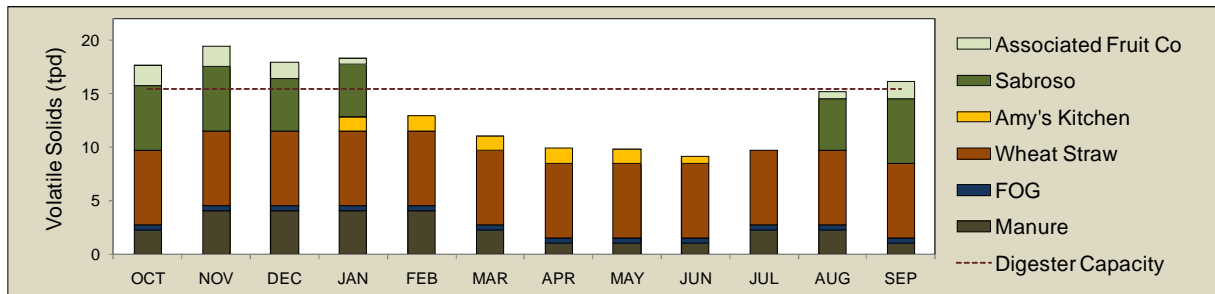
The availability and suitability for anaerobic digestion of each co-substrate varies considerably. Certain co-digestion feedstocks, such as food processor residues, show substantial seasonal variability. Combining the energy density of each substrate with the wet weight availability helps identify any limitation in consistent AD feedstock supply and provides an estimate of the likely methane yield. Unless tipping fees are realized or acquisition costs are prohibitive, energy dense substrates with a higher %TS, %VS and methane yield (such as fats) make more economic sense to source from a distance than less energy dense substrates (such as manures or dilute residues).

**Table 5 Methane potential of co-digestion feedstocks (EC Oregon, 2009)**

Co-digestion Feedstock	Tons per day	% TS	%VS of TS	Methane Yield (m <sup>3</sup> CH <sub>4</sub> / kg VS)	Mcf CH <sub>4</sub> per Day
<i>Dairy Manure (onsite)</i> <sup>(1)</sup>	78.4	6	52.5	0.180	14
FOG/GTW	5.7	30	90	0.572	28
Food Processor Residues <sup>(2)</sup>	16	25	95	0.336	59
Wheat Straw <sup>(3)</sup>	24	93	91	0.302	196
Municipal Food Waste	6	30	85	0.435	21
Poultry Litter	16	70	75	0.240	65

1. Data assumes cows are in pasture 40% of the time. Additional assumptions include 1) characteristics of manure entering digester mix tank after flush collection and thickening to 6% TS 2) bedding is incorporated and 3) up to 25% loss of volatile solids occurs due to flush collection.
2. Value shown is an average value. Food processor residues have seasonal variability ranging from 0 tpd to 27 tpd.
3. Based on county harvest averages from 1999-2008 for Jackson, Josephine, Douglas, and Klamath counties.

Although an optimized digester requires a steady consistent stream of feedstock, the seasonal decrease of manure from pasturing cows to meet organic dairy requirements will not adversely affect digester performance to a significant degree. Food processor residue from fruit and vegetable harvests also tends to be seasonal. If an exact consistently mix cannot be sourced, ensiling the food processor residue will help mitigate seasonal variability in volatile solids availability. However, ensiling will increase biogas plant capital and operational expenses. Any feedstock changes due to seasonal availability will need to be incorporated gradually in order to avoid underperformance or potential crashing of the digester.



**Figure 7 Seasonal Availability of Feedstock**

## 4. Proposed Digester Scenarios

In mid December 2008, EC Oregon sent out a Request for Information and Budgetary Cost Estimate (RFI) for two hypothetical dairy farms – one flush and one scrape manure collection. Vendors solicited were experienced with at least one of the following types of digesters: covered lagoon, plug-flow, hydraulic-mixed, induced blanket reactors and contact digesters. In addition to technical information and costs, vendors were asked to provide references for any recommended designs.

Most technologies were capable of addressing current farming practices or recommended minimal farming practice changes in order to utilize the co-digestion feedstocks. Vendor responses were reviewed by the following criteria:

- Suitability of technology to available feedstock
- Proven technology based on references
- Experience of the vendor and the availability of commissioning and support staff
- Conservative estimates based on true system evaluation data or reasonable literature values (non-extreme values or outliers)
- Competitiveness of the cost estimate

The final selection consisted of plugging variable data from RFI responses into a conservative financial model taking into account federal and state incentives, power purchase agreements, and other site specific variables to determining long term project viability and revenue. The model revealed that though capital expenditure is an important variable, three other variables were also influential when considering the lifespan of the project: 1) Energy Yield, 2) Parasitic Load, 3) Operations and Maintenance costs.

Although other technologies were less expensive, the combination of higher energy production, compatibility of co-digestion feedstocks, and lower operation and maintenance costs indicate certain types of complete mix (aka CSTR) technology were significantly more financially viable. This data supports conclusions drawn from literature as well: complete mix digesters offer the best solution for co-digestion of dairy manure.

### 4.1 PROPOSED BIOGAS PLANT SCENARIO

Therefore, a complete mix co-digestion scenario of flush manure collection is proposed. The flushed manure bedding mixture will be thickened to about 4% TS. Recovered liquid could continue to go to existing flush ponds for reuse or straight to the lagoon, provided no difference in quality is observed,. This scenario attempts to fully utilize on farm equipment with minimal disruption to current farming practices.

In order to minimize risks of incompatible bedding the recommended scenario is based on switching from bedding with wood content to the composted digestate solids produced through the digestion process. Noble Dairy currently receives 70% of their bedding for free. However, the remainder of the bedding is purchased at the rate of \$800 dollars per month. By switching to composted digestate solids Noble Dairy will realize an avoided cost of \$9,600 per year. However, using the digestate solids as bedding means that a portion of the bedding cannot be

sold. Using a bedding application rate of 10 lbs of bedding/cow/day, results in 2,000 tons of bedding needed per year. The current price (\$10/ton) Noble Dairy receives for their manure solids results in an opportunity cost close to \$20,000. Hence, a net opportunity cost greater than \$10,000 per year occurs as a direct result of switching the bedding. The impact of the net opportunity cost can be minimized so long as a certain economy of scale is used.

The following scenario focuses on a scale that minimizes opportunity cost impact while at the same time takes realistic advantage of available co-digestion feedstock. Flushed manure is thickened to a level that minimizes VS loss while keeping the TS of the blend below the required 13% for complete mix technology. Fats, oils and greases (FOG) are added at a ratio shown to improve methane yields without overloading the digesters. Straw, with high energy density per fresh weight, is sourced to boost overall methane production. Food processor wastes are added as available to fill the digester to ~95% capacity. Due to the seasonality of the processor waste stream, it is assumed it is blended with chopped straw and ensiled. If dairy herd size increases, the amount of processing waste could be replaced with the additional manure. Any synergistic effects of co-digestion could further improve methane production, but due to their unknown magnitude have been ignored in this scenario.

**Table 6 Feedstock regime of hypothetical complete mix biogas plant at Noble Dairy with co-digestion (EC Oregon, 2009)**

Jerry Noble - Scenario A. Complete Mix with Co-digestion - 10/30/2009

Feedstock	Annual Used	Used Daily	Total Solids (TS)	Volatile Solids (VS)	Methane Yield	Methane Production
	<i>US Tons / Year</i>	<i>US Tons / Day</i>	<i>(as is basis)</i>	<i>of Total Solids</i>	<i>m<sup>3</sup> CH<sub>4</sub> / kg VS</i>	<i>Mcf / Day</i>
Flushed/Thickened Manure	39,770	109	4.1%	59.5%	0.180	15.34
Dilution Water	-	-	0.0%	0.0%	-	-
Amy's Kitchen	2,760	8	18.0%	93.0%	0.336	13.67
FOG/ GTW	624	2	30.0%	90.0%	0.572	8.43
Wheat Straw	3,000	8	93.0%	91.0%	0.302	67.34
Sabroso	1,643	5	62.5%	97.0%	0.336	29.39
Associated Fruit Company	1,606	4	16.0%	97.0%	0.336	7.32
<b>Total</b>	<b>49,403</b>	<b>135</b>	<b>12.9%</b>	<b>84.3%</b>	<b>0.299</b>	<b>141.49</b>

This conceptual complete mix biogas plant would require up to two acres of land, including all required vessels, reception hall and biogas utilization equipment. The biogas plant would likely consist of the following components:

- One reception hall with
  - fiber/feedstock storage
  - control/lab room
  - pumping manifold
  - CHP or boiler unit(s)
  - dewatering equipment
- One feed storage tank for liquid feed (if necessary)
- One feed reception pit / mix tank
- One primary anaerobic reactor
- One post digester with integrated biogas storage
- Lagoon (existing) for centrate storage
- Access road and long-term feedstock storage would require additional land

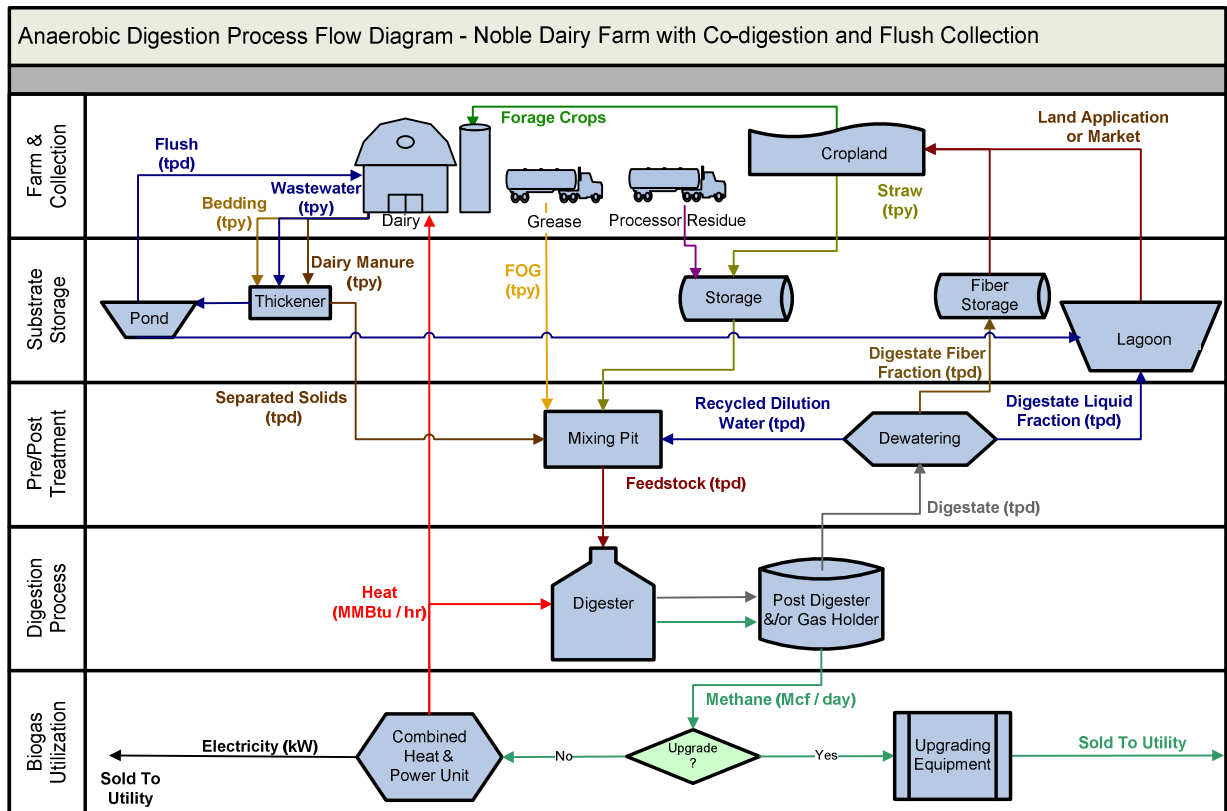


Figure 8 Process flow diagram of potential on farm biogas plant with co-digestion (EC Oregon, 2009)

The process flow for this digestion system is presented above and the following table provides corresponding details. The kW estimate is net for a CHP operating at ~40% efficiency. Since biogas – and hence electricity – can be produced 24 hours/day, 365 days/year (unlike solar or wind installations), an estimate with 10 days of annual CHP maintenance is provided.

Table 7 Process flow values complete mix biogas plant at Noble Dairy with co-digestion (EC Oregon, 2009)

Jerry Noble - Scenario A. Complete Mix with Co-digestion - 10/30/2009

Feedstock	US Tons / Year
Flushed/Thickened Manure	39,770
Dilution Water	-
Amy's Kitchen	2,760
FOG/ GTW	624
Wheat Straw	3,000
Sabroso	1,643
Associated Fruit Company	1,606
<b>Total</b>	<b>49,403</b>

Gas Yield	Mcf / Day
Biogas	236
Methane	141

CHP Outputs		
Electricity	kW	616
Electricity	kWh / Year	5,245,790
Jacket Heat	Million BTU / Hour	1.72
Exhaust Heat	Million BTU / Hour	1.73

Digester	US Tons / Day
Daily Feedstock Mix	135
Digestate	126

Dewatering		
Fiber	Yards <sup>3</sup> / Year	14,923
Liquid Fraction	US Tons / Year	39,206

In this co-digestion/CHP scenario, the amount of biomethane produced would produce more waste heat than could be used efficiently on farm. In that case, an investment into biogas upgrading equipment to allow for natural gas grid injection may be warranted. However, at the present time Northwest Natural has yet to accept upgraded biomethane into their grid. Therefore, upgrading and injecting biomethane is seen as more of a long term possibility rather than a short term reality. If upgrading and injection is implemented, a boiler will be required to maintain mesophilic temperatures in the digesters.

Noble Dairy is located in Pacific Power (PacifiCorp) service area. In this co-digestion scenario, more energy will be produced than is currently used at the Noble Dairy so a “sell all” power purchase agreement with PacifiCorp is the preferred option. Interconnection, while costly (~\$150k) and lengthy (up to 12 months), would be a requirement. In addition, since the electricity is produced from a renewable source, the biogas plant is eligible for Renewable Energy Credits (aka “green tags”). A manure-only scenario that considers losses from grazing and flush water thickening would produce 50-75 kW. This range of electricity production could warrant a net-metering situation, since the farm is estimated to use 100-120kW. However, designing a system at this scale that is financially viable (with low enough capital and operational expenditures) is challenging.

Effluent is sent through a screw press separator to produce fiber and liquid co-products. The portion of fiber used as bedding would be unavailable for sale; the remainder is sold to agricultural or horticultural customers. On site space for composting and/or storage of fiber will need to be identified; waste heat produced by the CHP could be captured to dry the solids if warranted. The nitrogen in the digested liquid fraction will largely be converted from an organic form to a form readily available for plant uptake (ammonium), however it is assumed neither revenues nor costs are realized for the liquid digestate. Liquid digestate could continue to be land applied at the home ranch and the satellite farms; verification of nutrient management plans will be needed.

Much of the daily operation of a modern biogas plant is automated. A well designed process control system will collect data, monitor performance, sound alarms (remotely) and provide process control via feedback loops. A low-tech digester operating on manure alone would require 1 hour/day of oversight, plus an additional 15 hours of monthly maintenance. A full scale biogas plant, importing multiple feedstocks, and running on CHP could require one or more full-time employees.

Multiple ownership models are available to Noble Dairy depending on financial goals, fiscal situation and level of acceptable risk. If the dairy is able to provide adequate equity and collateral, a single owner scenario is a possibility. Another common scenario is to create a business entity (project company) with one or more third party investors. Exact ownership details would be dependent on the terms of a resource agreement between the farm and the project company. Likely terms include: the dairy supplies land and manure to the project company in return for dewatered fiber in sufficient quantities for use as bedding and liquid effluent in sufficient quantities to fertilize existing forage acres; excesses are managed by the project company. All capital and operational expenses are also typically covered by the project company.

## 5. Financial Analysis

### 5.1 BASE CASE SCENARIO

Combining the assumptions, technology dependent variables, and feedstocks provides insight into overall biogas financial viability. Conservative, yet realistic, values were used to produce financial analysis. Feedstock is typically the primary operational expense for a biogas plant. The cost of collecting, transporting and delivering of external feedstocks would need to be carefully assessed once a supplier is identified. In all scenarios, manure is procured for the biogas plant under "business as usual" assumptions at no additional cost to the farm; a tax credit is also realized by the farm. It is assumed that transportation costs for food processor wastes and greases from Medford will be covered by the generator in exchange for the right to "tip" the substrates at the biogas plant. Straw is purchased for the proposed scenario at a rate less than the farm currently pays for wheat straw. This cost is deemed reasonable considering an economy of scale will be realized by the large volume, and tax credits and other incentives will be available to the grower.

**Table 8 Financial model assumptions**

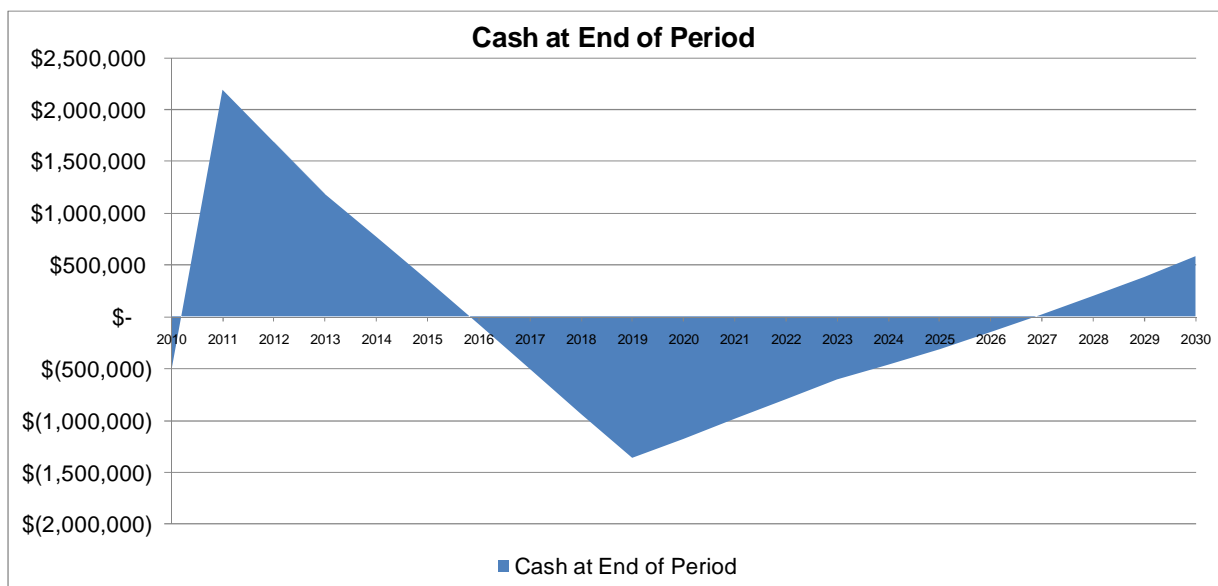
<b>FEEDSTOCK</b>	
Dairy Manure	\$5 / Ton Biomass Producer Tax Credit (through 2012)
Dilution Water	None required (use flush water)
Food Processor Waste (tipping fee)	\$0, (tipping fee needs to be negotiated)
Wheat Straw (purchase price)	\$35 / Ton harvest and transport
FOG (purchase price or tipping fee)	\$0, (tipping fee needs to be negotiated)
<b>BIOGAS PLANT</b>	
Digester Technology	Complete Mix
Organic Loading Rate (kg VS/ m <sup>3</sup> / day)	4.0
Inflation Rate	3%
Digester Capital Expenditure Contingency	30%
<b>RENEWABLE ENERGY</b>	
Year One On-Peak Price per kWh	\$0.0568 <sup>(1)</sup>
Year One Off-Peak Price per kWh	\$0.0434 <sup>(1)</sup>
Starting Dollar per REC	\$7.75
CHP O&M (\$/kWh)	\$0.015
<b>NUTRIENT RECOVERY</b>	
Solids Capture Rate	70%
Fiber Value (\$ US / Yards <sup>3</sup> )	\$4.50
% Fiber to sell	70%
Liquid Nutrient Value / US Ton	Not valued
<b>FINANCIAL</b>	
Debt Financing : Equity (% Ratio)	75 : 25
PTC/ITC option	ITC Grant
Loan terms	10 year, 6.5%, 2 points
Business Energy Tax Credit	Passed-through (sold at 33.5% of eligible project costs)
Depreciation	MACRS + ARRA-enabled Bonus
Other incentives	\$500k USDA grant

1. PacifiCorp Power Purchase Agreement (Assumes commissioning date of January, 1 2011), [PacifiCorp - Oregon Schedule 37 (September 9, 2009)].

Accurately calculating potential carbon credits is dependent on numerous variables; flush systems and co-digestion further complicate the equation. Therefore, a conservative approach was taken and carbon credits were not valued as an additional revenue stream. Note though, the herd size combined with decreased manure collection due to pasturing requirements may prevent Noble Dairy from reaching the threshold where monetizing carbon credits is financially rewarding – at least at current carbon credit prices.

Other major annual expenses include operation and maintenance (O&M) for both the anaerobic digester and the CHP. In addition, both the digester and CHP have electrical demands, slightly reducing the net amount of available electricity. These parasitic loads are usually relatively small compared to some other conversion technologies. Major financial components are detailed below.

The cash flow for this scenario is not sufficient to recoup the initial investment in a timely manner. After commissioning (year 2011) multiple renewable incentives are monetized. However, over the next several years the cash at the end of the period decreases due to debt financing and depreciation. Printouts of the pro forma financial modeling are provided in the appendices for this section.



**Figure 9 Biogas plant projected cash flows (EC Oregon, 2009)**

**Table 9 Proposed base case scenario**

Anaerobic Digester at Noble Dairy Farm with Co-digestion and Flush Collection	
Manure Collection	Flush Collection
Digester Technology	Complete Mix
% Manure of Co-digestion Feedstock Mix <sup>(1)</sup>	18%
Mcf Methane / Day	141.5
Biogas Utilization	Combined Heat and Power
Electricity Production (kW)	622 kW
Biogas Plant Capital Expenditure <sup>(2)</sup>	\$5,670,029
• Digester Capital Expenditure	\$3,341,693
• CHP Capital Expenditure	\$1,088,996
Revenue / Year <sup>(3)</sup>	\$356,211
• <i>Electrical Revenue</i>	\$267,137
• <i>Fiber Revenue</i>	\$48,419
• <i>Green Tag Value</i>	\$40,655
Total Expenses / Year <sup>(4,5)</sup>	\$ (291,865)
• <i>Feedstock Direct Expense / Year</i>	\$ (108,150)
• <i>Digester Operations &amp; Maintenance / Year</i>	\$ (79,429)
• <i>CHP Operations &amp; Maintenance / Year</i>	\$ (83,554)
Baseline Operating Net Income <sup>(6)</sup>	\$ 74,223
Return on Investment <sup>(7)</sup>	21+
Return on Equity <sup>(7)</sup>	1.6
Internal Rate of Return <sup>(7)</sup>	1.9%
Net Present Value <sup>(8)</sup>	\$ (622,621)

1. Based on volatile solids basis
2. Assumes the total capital expenditure for the project can be controlled at a contracted amount
3. On-peak rate and off-peak rates stated in Financial Model Assumptions Table
4. Total Expense / Year excluding depreciation and interest expense
5. For "baseline" year (i.e., will increase with inflation)
6. Earnings Before Interest, Taxes, Depreciation and Amortization
7. Calculated on pre-tax basis
8. Net Present Value assume 5% discount rate

## 5.2 BEST CASE SCENARIO

Since the base case scenario is modeled somewhat conservatively, a number of measures can improve the overall financial outlook. There are numerous factors that could be negotiated, or require slight changes in farming practice or policy extensions in order to improve the financial viability. Capital expenditure and feedstock blend were held constant. The best case scenario models the following assumptions.

- Negotiating a nominal tipping fee – after transportation – for food wastes (\$10/ton) and waste grease (\$0.10/gallon) will significantly reduce net feedstock acquisition cost.
- The Biomass Crop Assistance Program (BCAP) can be used to offset the cost of wheat straw with a dollar for dollar USDA match resulting in a significant reduction in feedstock acquisition costs, at least through 2012.
- Bundling green tags into a negotiated power purchase agreement of \$80 / MW with a 1% annual rate increase, will realize significantly more revenue than with the current PPA.
- A portion of the wheat straw could be used as bedding, hence allowing all fibers to be sold. The remainder of the straw would be available for ensiling food processing residue.
- Lowering the debt to equity ratio to 65:35 (from 75:25) via grants or other means significantly reduces financing costs.
- Taking advantage of low interest loans, such as the Farm Storage Facility Loan, for qualifying project costs would further reduce the amount of interest paid.

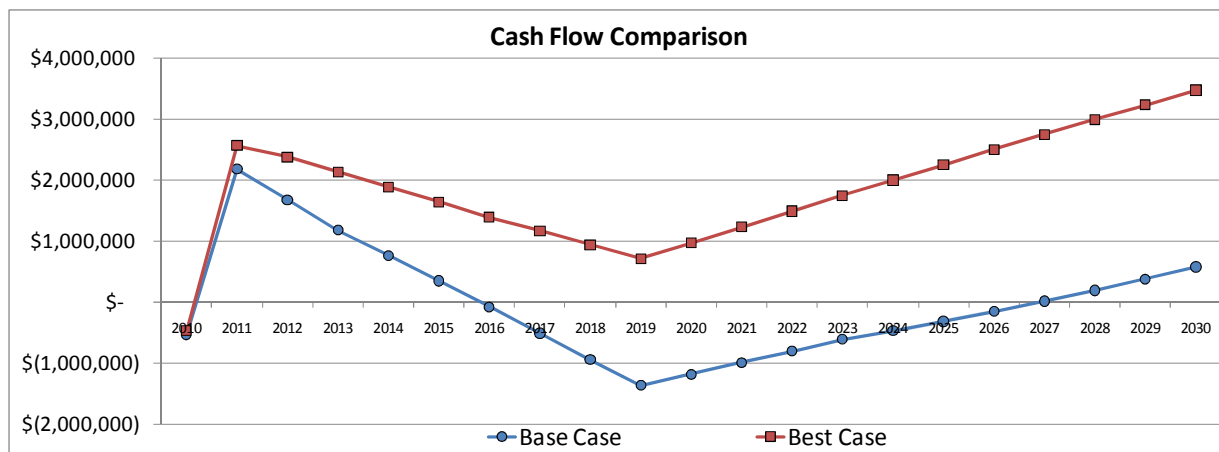


Figure 10 Cash Flow Comparison (EC Oregon, 2009)

The comparative analysis between base case and best case scenarios indicates significant improvement through the prudent control of the previously mentioned variables without having to compromise on digester technology via reduced CapEx. The best case scenario results in a moderately attractive return, sufficient to attract investment interest (see Table 10). While the base case is considered realistically achievable, the best case would take aggressive pre-development and on-going management effort.

**Table 10 Financial viability comparison**

<b>Parameter Changed</b>	<b>ROI (years)</b>	<b>ROE (years)</b>	<b>IRR</b>	<b>NPV</b>
Base Case Scenario	21+	1.6	1.9%	\$ (622,621)
Best Case Scenario	11.1	1.7	20.1%	\$2,863,127

Other means of improving financial viability that were not included in the best case scenario include:

- Identify a use for the waste heat from the CHP. For example, monetizing jacket and exhaust heat could produce over \$57,000 in additional annual revenue (based on current natural gas hub prices of \$3.82 / MMBtu) or avoided costs of over \$340,000 per year (based on current propane costs of \$2.261/ therm).
- Develop the market for the effluent co-products. In these scenarios, dewatered fiber has been valued as a bedding replacement at \$10 / ton. However, market studies suggest fiber could have a niche in the nursery industry as a planting media (peat moss replacement) with potential for \$20 / ton or more. Further, the nutrients in the digestate liquid stream have not been valued here.

## 6. Conclusions & Recommendations

Anaerobic digestion of dairy manure is proven technology, immediately available for commercial applications from an ample number of qualified vendors with flexible designs. For the most part, on farm practices at Noble Dairy are technically compatible with anaerobic digestion. The widely preferred approach in Germany and Austria (the world leaders in AD) is to use “complete mix” digester technology, operating at mesophilic temperatures and utilizing multiple co-digestion feedstocks. Based on this fact in conjunction with recent vendor responses and financial modeling, it is recommended that Noble Dairy consider a co-digestion scenario with a complete mix digester, producing electricity from a CHP sold under a “sell all” power purchase agreement.

Since dairy manure is not a particularly energy dense AD feedstock, returns on dairy digesters are often marginal without co-digesting energy dense materials. Straw is a good match for liquid dairy manure and has high relatively high energy density, however is difficult to source in the Applegate Valley. Fats, oils and greases, sourced in small quantities, can disproportionately boost biomethane production. Noble Dairy potentially has access to multiple food processor waste streams from Medford.

A base-case scenario is proposed that offers feedstock flexibility, consistent methane production, pathogen reduction, nutrient management, high quality fiber bedding and odor control. The potential for diversified revenue and/or avoided costs to the dairy could help mitigate recent fluctuations of milk prices and energy and feed costs. The proposed co-digestion scenario using straw, fats/oils/greases and food processor waste produces biomethane at a rate of approximately nine times that of a manure only approach. However, financial modeling using conservative, yet realistic assumptions, results in returns that are likely not adequate to attract investment interest. The proposed base case biogas plant requires an initial capital expenditure of \$5.7M, has a return on investment of 21+ years and 1.9% internal rate of return.

A best case scenario was developed that holds feedstock blend and capital expenditures constant while assuming the following improvements can be realized:

- Source food wastes that receive modest net tipping fees, after transportation costs
- Mitigate straw acquisition costs using federal and state biomass incentives
- Incorporate a portion of the straw as cow bedding to increase fiber sales and revenues
- Negotiate power purchase agreement that considers wheeling and green-tag bundling
- Reduce debt:equity ratio and financing costs via grants, low interest loans and/or other means

Financial metrics on the best case improve to a return on investment of 11.1 years, a 20.1% internal rate of return and a net present value of \$2,863,127. It is important to note that the best case scenario, although achievable, would present considerable challenges. Additional measures, such as developing markets to add value to fiber and fertilizer co-products or identifying an on-farm use for CHP waste heat – potentially adsorption chilling of milk – can further improve the investment opportunity.

## Appendices for Section 1

### ADDITIONAL BENEFITS

The Oregon Department of Energy sites the following advantages and benefits of manure digesters in conjunction with livestock operations:

1. Greatly reduce odor levels, by 90% or more.
2. Reduce bacteria/pathogens: heated digesters reduce pathogen populations dramatically in a few days; additional post-digester composting can ensure pathogen-free end products.
3. Nutrient management - In the process of AD, the organic nitrogen in the manure is largely converted to ammonium, the primary constituent of commercial fertilizer, which is readily available and taken up by plants. Much of the phosphorus is removed through the solids, allowing for more balanced nutrient applications.
4. Co-generation and energy cost reduction - Anaerobic digesters produce methane gas which can be captured for generating electricity for on farm use. If the operation is large enough, potential sales of excess power back to the grid may be possible.
5. Final products - the final products of AD are quite suitable for composting and used either on the farm as bedding material or as a soil amendment, or sold off the farm as an organic based fertilizer/soil enhancer.

### FERTILIZER

Effluent from the AD process, called digestate, includes a wet fraction that can be utilized as a marketable agricultural fertilizer and a solid fraction which makes an ideal compost component. The AD process should render all weed seeds unviable. By coupling AD and fertilizer/compost production, the feedstock is optimally utilized and provides excellent soil amendments while reducing the amount of material in local landfills and wastewater treatment plants. In the EU anaerobic digestate is becoming an important source of certified organic fertilizer as petroleum based fertilizer costs rise and conventional acreage is converted to organic. Suspended solids remaining in the digestate effluent after separation will be composed of smaller particles than the liquid fraction of undigested dairy manure and is therefore unlikely to clog irrigation equipment. This in return benefits the farmer in reduced operation and maintenance costs.

### PATHOGEN REDUCTION

In addition to weed seed destruction, AD results in dramatic reduction of the bacterial pathogen populations. Anaerobic digestion significantly reduces total pathogenic organisms. The reduction rates of the following specific pathogenic organisms: environmental *Streptococcus* species, coliform bacteria (including: *Escherichia coli*, *Klebsiella* species, and *Enterobacter* species), *Mycobacterium Avium paratuberculosis* (Johnes disease bacterium) have been frequently monitored and show better than 92% reduction in each species or group. Other organisms not listed as a genus are often grouped, such as total gram negative organisms, and are also significantly reduced with AD. Common pathogens in poultry litter (a potential co-digestion feedstock), such as *E. coli*, *Salmonella*, and *Campylobacter*, are unlikely to survive AD due to prolonged exposure to at least mesophilic temperatures. Further, if AD is combined with post-digester composting, a pathogen-free end product is virtually assured.

## **BEDDING FOR DAIRY COWS**

Although AD has been shown to reduce pathogenic organisms by > 92% and in some cases > 99%, there is a slight risk of mastitis associated with improper management of digested solids. In incidences where mastitis occurred, veterinarians suggested that the solids were not dry enough and that the moisture contributed to mastitis.

Cases have been shown where digester effluent showed 2-3 log fold decrease in some pathogens while composting the effluent solids reduced the pathogenic levels even further. However, composting may reduce the bedding volume by up to 40%. Using composted digested solids as bedding seemed to improve cow comfort, showed better foot and leg health, and cows spent more time lying down. Owners believed this increased comfort was due to an increased bedding thickness from < 25 mm (0.98 in) to a bedding thickness > 25 mm (0.98 in) but < 75 mm (2.95 in). Proper ventilation allowed the solids to dry in the stalls which may have helped reduce pathogenic growth and transfer. Since the bedding still contains some organisms, the maintenance plan for stalls, bedding, drying solids, alley cleaning, and removing organisms from teat prior to milking must be properly followed to minimize mastitis risk (Meyer et al., 2007).

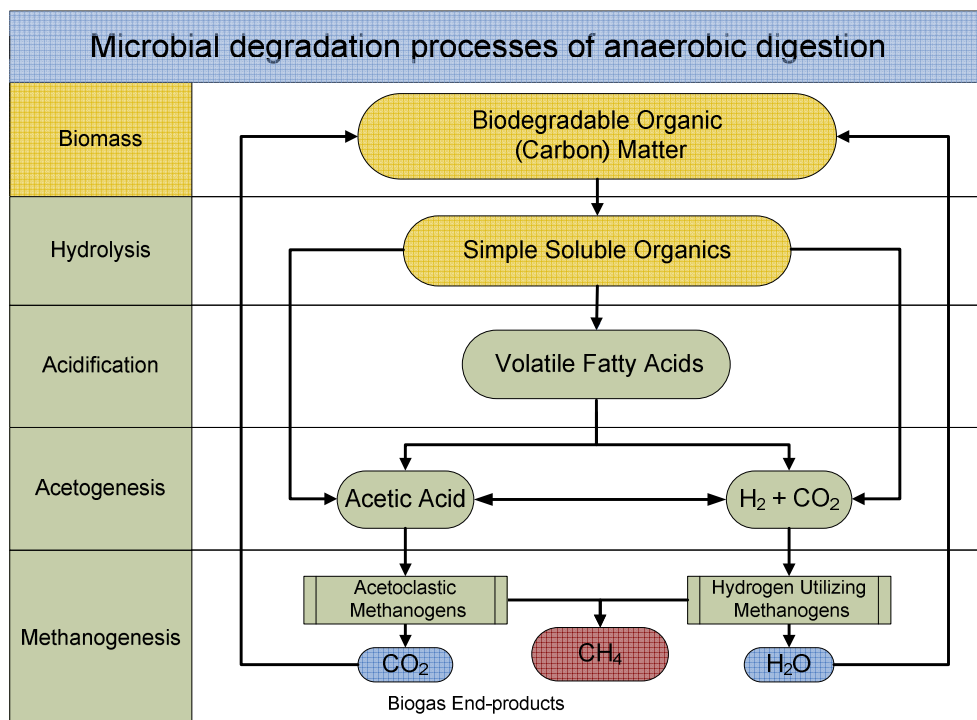
For dairies already using composted manure solids, no increase of somatic cell counts or incidence of mastitis is anticipated using composted digested solids as bedding as long as moisture is controlled. A common practice in the Willamette Valley is to apply hydrated lime as a bedding drying agent. Additional moisture control of bedding may be available to dry composted solids with waste heat from a CHP system; this may reduce or eliminate the need for hydrated lime.

One digester vendor indicated that since the digestate has had 99% of the pathogens removed, the digestate can be used safely as bedding without composting or the use of hydrated lime. Before switching to a non-composted practice for digestate solids, EC Oregon recommends testing the solids for pathogens.

## Appendices for Section 2

### ADDITIONAL BACKGROUND

Biogas production is the result of a complex sequential biological process, in which the substrate is continuously broken down. Hydrolytic enzymes reduce complex organic polymers to monomers and oligomers; acidogenic bacteria utilize these simpler compounds to form organic (volatile fatty) acids; acetogenic bacteria then convert the long chain acids to acetic acid; finally, methanogens create methane ( $\text{CH}_4$ ),  $\text{H}_2\text{O}$  and  $\text{CO}_2$  from precursors formed in the previous steps.



**Figure 11 Microbial degradation processes of anaerobic digestion (EC Oregon, 2009)**

There are multiple reasons for the increased interest in biogas, foremost being energy efficiency. Based on life cycle analyses, biomethane has 3-5 times more energy yield from an acre of land than other biofuels (De Baere, 2007). It also has versatility as fuel for electricity, heat and vehicle fuel, and can be transported efficiently via natural gas pipeline to optimal end-users. Biomethane can be created from numerous high-yielding energy crops, from multiple harvests and – perhaps most significantly – from a wide variety of waste streams.

In Germany, the world leader in renewable energy production, biogas plants produced over 11 billion kWh in 2008. There are approximately 4,000 biogas plants in Germany alone with installed electrical capacity of 1,400 MW, including large scale facilities with capacity greater than 20 MW. A partial summary of biogas facilities illustrates the widespread use of the technology.

**Table 11 Anaerobic digestion facilities worldwide (EC Oregon, 2009)**

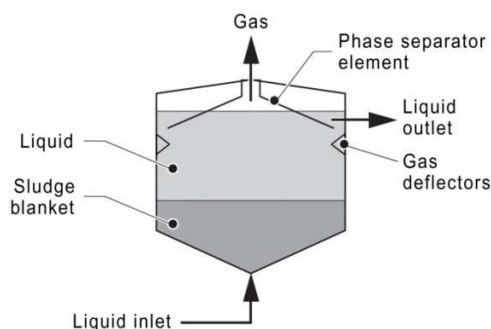
Region	Feedstock Type	Number of Facilities	Source	Year Published
Worldwide	Municipal Solid Waste (MSW)	185	International Energy Agency, Bioenergy Taskforce	2002
United States	Municipal wastewater	3500	US Dept of Energy, (EERE)	2005
Worldwide	Industrial wastewater	1600+	Journal of Chemical Engineering	2003
Germany	Agricultural wastes	4000	German Biogas Association	2009
Worldwide	Ethanol distillery stillage	149	Journal of Biomass and Bioenergy	2000
China	Village & farm waste	~15 million	UN Economic and Social Commission for Asia	2005
United States	Livestock manure	135	AgSTAR Program (USDA, EPA, Dept of Energy)	2009

### **HIGH RATE DIGESTERS**

High rate digesters attempt to improve upon the traditional technology and tend to reduce the SRT while increasing the OLR. Due to clogging issues and only being able to process soluble fractions, high rate digesters do not tend to be recommended for dairy manure systems. Examples of high rate digesters follow which describe appropriate conditions for their use.

#### **Upflow Anaerobic Sludge Blanket (UASB)**

Granulated sludge remains fixed in the base of the reactor, as effluent is passed upwards through the sludge bed. UASB is considered very high rate and as such has a small footprint, however it is only applicable to waste streams with low solids content. Although UASB reactors are compact, produce methane, have low operational costs and produce little sludge when treating wastes that are dilute and easily digested, they have had mixed results when harder to digest wastes are used. The granules are sensitive to common AD parameters, such as, pH, alkalinity, temperature and OLR. If gas flow or production suddenly increases within the UASB the granules may undergo shearing due to the increased velocity. High concentrations of calcium (associated with lime) or iron can create precipitates that could clog the reactor. Not easily digested solids could also clog the digester. Although fats, oil and grease (FOG) have been shown to increase methane production in other types of AD, problems like low efficiency, low granulation, foaming, scum formation, and sludge washout may occur when FOG is added as a waste substrate to UASB system.



**Figure 12 Upflow anaerobic sludge blanket (Scott, 2005)**

### **Induced Blanket Reactor (IBR)**

An induced blanket reactor is a modified version of the UASB digester designed for HRT of 5 to 8 days. With a sludge blanket maintained within the bioreactor, slow growing bacteria are retained in the tank which accelerates digestion of slurry. The technology consists of multiple above ground tanks with high height to diameter ratios. Solids and slow growing bacteria are retained on a septum with a plugging control mechanism; subsequent formation of a sludge blanket consisting primarily of bacteria occurs in the lower portion of the tank. The tanks are designed as flow through systems with influent entering at the bottom and effluent exiting through the top with a modular design allowing for isolation and repair of failed tanks. As methane bubbles up, bacterial aggregates of methanogens float up to the septum. The septum separates the methanogens from the gas, bacteria return to the bottom of the tank and gas exits via the septum. Additional recirculation of the effluent helps retain any bacteria bypassing the septum.

### **Fixed Film (or Anaerobic Filter)**

In a fixed film system, bacteria are retained in the digester and attached to a media with high surface area (sand, beads, matrix, etc); processing at a high rate, in as little as hours, with a small footprint. Fixed film systems are very efficient at degrading soluble constituents, but not particulates (i.e., only suitable for very low solids). Fixed film designs require separation of solids prior to digestion and are still prone to clogging under dairy farming practices. For example a fixed-film digester which was fed manure and calcite (calcite was added to the barns and stalls) clogged due to calcium buildup requiring conversion to a high-rate vertical plug-flow anaerobic digester.

## CONTACT DIGESTERS

Contact digesters retain biomass in the system, reduce the loss of microbial mass and increase SRT. Since bacteria are recirculated through this system, raw material and energy are not required to replace bacteria which results in more feedstock being converted to methane.

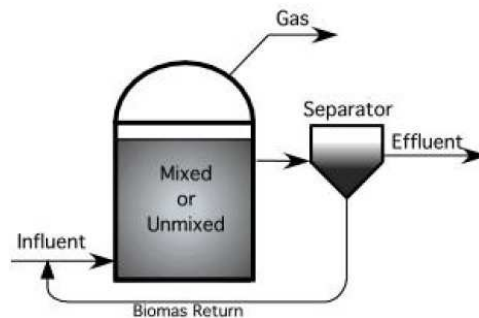


Figure 13 Contact reactor (Burke, 2001)

### Anaerobic Contact Process (ACP)

After digestion, effluent is degassed and settled in a separator or gravity tank; solids are returned to the main digester for further degradation. Mechanical methods such as centrifuges, presses, and membranes have been used to speed the separation process.

### Anoxic Gas Flotation (AGF)

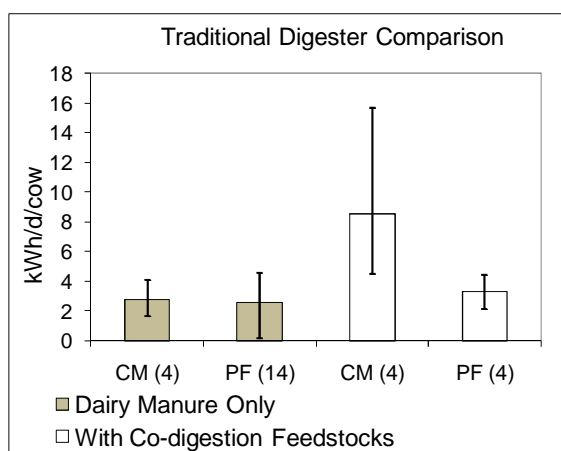
Separation is performed by bubbling effluent with anoxic gas – degassing is not necessary – and solids are skimmed off the top. AGF vendors claim the technology is physically gentler on the bacterial colony than mechanical separation allowing for greater productivity.

### Sequencing Batch Reactor (SBR)

The same tank is used for digestion and separation. Multiple tanks are operated in batch mode: feed, stir, settle, decant. Different feedstocks may be routed to smaller, parallel tanks to accommodate varying degradability. Tanks may be taken off-line when not needed.

## SUPPORTING DATA FOR TECHNOLOGY ASSESSMENT

When comparing case study data for digester technology with dairy manure as the sole feedstock there was no difference between plug-flow and complete mix reactors. The range of energy output varied widely though with co-digestion feedstocks suggesting either the system designs or operating and maintenance issues may contribute to differences in energy output for the plug-flow systems. Since dairy manure has rather low energy density, one does not expect to see much difference in energy output between digesters when dairy manure is used as the sole feedstock. However, when energy dense feedstocks are added as part of a co-digestion feedstock practice, the range of energy output greatly increases. Complete mix reactors show the largest potential energy output compared to plug-flow designs.



- Shows actual production values in kWh/day/cow for complete mix (CM) and plug flow (PF) digesters
- Number (n) of samples in parenthesis
- Y-axis = mean kWh per day per cow
- Error bars represent minimum and maximum values
- Mean (brown and white boxes), minimum (black error bars) and maximum (black error bars) kWh per day per cow were calculated for each digester.
- Dairy Manure Only (brown) shows case study data for when dairy manure is the sole feedstock.
- With Co-digestion Feedstocks (white) shows case study data for when co-digestion feedstock was available.

Data was compiled (EC Oregon, 2009) from Kramer 2004, Kramer 2008, Lusk 1998, Wright 2003, Wright 2004, Topper 2008, Martin 2003, Martin 2006, Martin 2007, Walters 2007, and Sjoding 2005.

**Figure 14 Energy output based on digester design and feedstock practice**

## Appendices for Section 3

### CO-DIGESTION BACKGROUND

Co-digestion refers to the process of utilizing multiple waste streams in an AD system for the purpose of increasing the biogas yields and optimizing the degradation of the waste. This process can potentially allow biogas plants to increase their renewable energy generation beyond site demands, thereby producing surplus electrical power for supply to the grid and surplus heat energy for supply to co-located facilities. For agricultural users, certain energy crops can be grown and stored for the express purpose of co-digestion, buffering seasonal processing feedstocks while adding value to rotational crops. The use of agricultural residue, as well as purpose grown energy crops, is rapidly increasing at European biogas plants.

The ability to take in co-digestion substrates allows the owner to take advantage of the economy of scale principle while digesting higher energy feedstock. This in turn enhances the financial feasibility as well as the profitability potential. Certain co-substrates can produce a disproportional increase in biogas production relative to the feed percentage. The high energy content and low acquisition cost of these substrates can justify the sourcing of smaller quantities and collection from longer distances. In Europe, farms compete for the limited supply of fats, oils and grease (FOG) based on its co-digestion amenability.

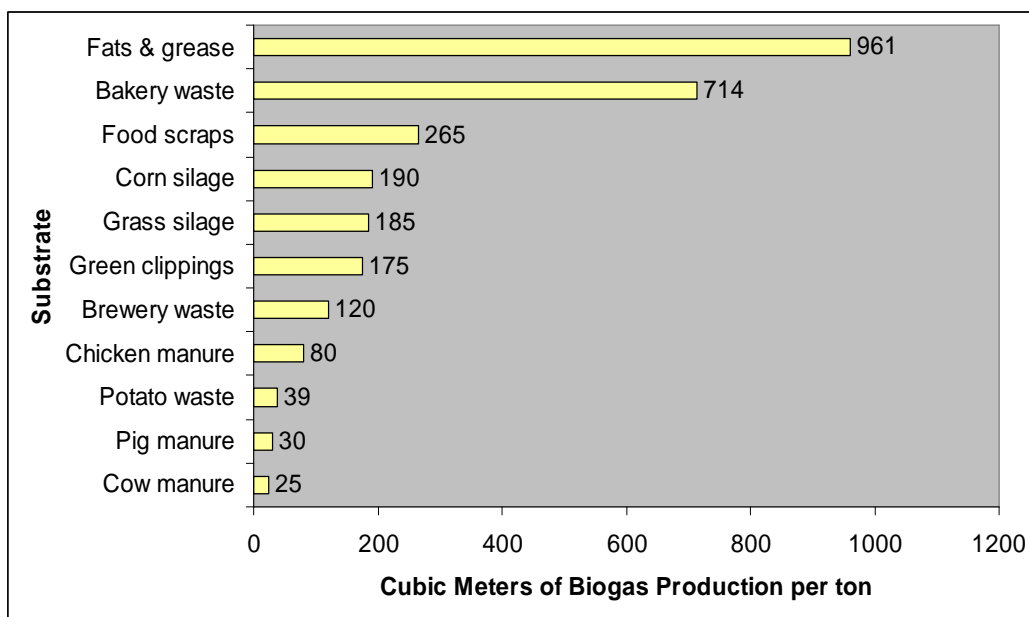
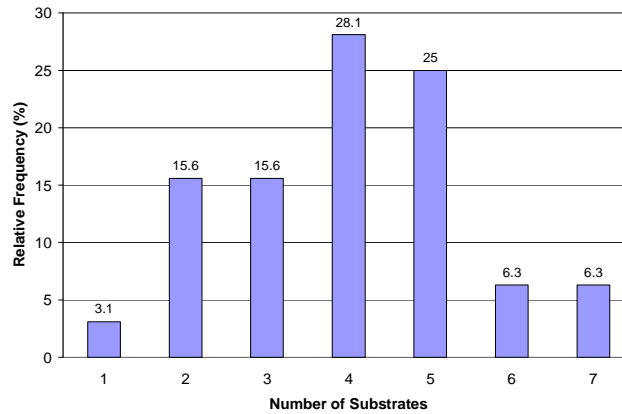


Figure 15 Cubic meters of biogas production per ton of substrate (Redrawn from Kramer, 2008)

A single feedstock rarely contains the proper balance of micronutrients for optimal methane production. Though dairy manure is not as energy dense as other substrates, it provides a good buffering system and essential micronutrients for AD while benefiting from the addition of high methane feedstocks. Multiple feedstock co-digestion is often the best way to ensure a balanced biological system. The frequency distribution of anaerobic digester systems utilizing multiple feedstocks or substrates in the EU is presented in the following chart.



**Figure 16** Frequency distribution of “Number of Substrates” for AD facilities built in EU, 2003 – 2005 (Hopfner-Sixt, et al. 2005)

An optimized mix of co-digestion substrates can greatly increase methane production; however a non-optimal mix will produce adverse effects resulting in decreased methane production and VS destruction. Adverse effects may be related to pH, ammonia toxicity, alkalinity or high volatile acid concentrations. The potential pitfalls of a non-optimal mix can be mitigated by adding manure to the mixture which increases the buffering capacity and provides essential nutrients. Feedstocks high in lipids and carbohydrates (e.g. oil and fresh pasta) with high VS are good feedstocks for co-digestion with manure.

The following table indicates the increased methane yields as other substrates are co-digested with dairy manure. Documented values for the methane yield of dairy manure as a sole feedstock tend to vary, however conservative values tend to be more true to realistic applications.

**Table 12** Examples of co-digestion with dairy manure

% Manure	% Co-digestion feedstock	Methane yield m <sup>3</sup> CH <sub>4</sub> / kg VS	Data Source
Manure (92 %)	FOG (8 %)	0.379	Crolla, 2006 <sup>(1)</sup>
Manure (88 %)	FOG (12 %)	0.403	
Manure (50 %)	Corn Silage (50 %)	0.361	
Manure (80 %)	Canola press cake (20 %)	0.423	
Manure (68 %)	Food waste (32 %)	0.219 - 0.429	El-Mashad, 2007 <sup>(1,2)</sup>
Manure (52 %)	Food waste (48 %)	0.277 - 0.556	
Manure (100 %)	-	0.140	Chen, 2008 <sup>(3)</sup>
Manure (94 %)	Glycerin (6 %)	0.220	
Manure (91 %)	Glycerin (9 %)	0.310	
Manure (100 %)	-	0.243	Labatut, 2008 <sup>(3)</sup>
Manure (75 %)	Plain Pasta (25 %)	0.354	
Manure (75 %)	Vegetable Oil (25 %)	0.361	
Manure (50 %)	Dog food (25 %) Ice cream (25 %)	0.467	

1. Values for methane yields shown for these references were calculated assuming a 55% methane content of the biogas yields listed.
2. Varied loading rate at 2 g VS / L / day and 4 g VS / L / day in a continuous flow system.
3. Methane yields were reported for these references and not calculated.

## BIOMETHANE YIELD LABORATORY TRIALS

Biochemical Methane Potential (BMP) is an analytical tool that describes the volume of methane (CH<sub>4</sub>) that can be produced from a given amount of volatile solids (VS) for a particular feedstock; it is expressed as m<sup>3</sup>CH<sub>4</sub>/kg VS. The BMP assay was designed to simulate a favorable environment where degradation will not be impaired by nutrient or bacterial deficiencies, toxicity, oxygen, pH, over-feeding, etc. In this way, relative biodegradability of various materials can be compared. It should be noted, BMP values reflect the ultimate methane production from a feedstock; actual yields in commercial applications may vary.

### Area Dairy Manure Samples

Representative samples from two dairy farms operating under “normal” practices for dairy farms in the Willamette Valley were collected in November of 2008. Both farms have a freestall barn layout; however, manure collection at one farm used a scrape based method versus a flush based system at the other farm. In both cases homogenized samples were sent to Woods End Laboratories in Mt Vernon, Maine for analysis using a variation of the method DIN 38414 from German Standard Methods for the Examination of Water, Wastewater and Sludge, which calls for a 21 day trial length.

Results of the BMP testing for all samples showed degradation started immediately (no lag time) and neared completion around 21 days. The BMP tests were done at two different organic loading rates (OLR) with the higher OLR (4 kg VS/L) twice that of the lower OLR (2 kg VS/L). In all cases, BMP results were consistent with literature values and had a biogas content of 63% methane or better. As OLR increased, the flush samples produced higher methane yields indicating the higher loading rate did not overload the methanogens; a result that may carry over to commercial scale. Conversely, the scrape samples resulted in decreased percent methane of the biogas, as well as methane yield; this indicated the digester system had been overloaded. The microbial environment becomes unstable due to accumulation of volatile fatty acids, pH shifts, ammonia accumulation, or changes in alkalinity thus resulting in stressed bacteria and decreased productivity. This indicates there are tradeoffs to be considered regarding throughput and digester size. On one hand a low OLR requires a larger and potentially more expensive digester, but will yield more methane. The other option of using a smaller and potentially less expensive digester will require higher loading rates with reduced methane yields.

**Table 13 Local dairy manure biochemical methane yields (EC Oregon, 2009)**

Manure Handling	Organic Loading Rate	m <sup>3</sup> CH <sub>4</sub> /tonne fresh weight	m <sup>3</sup> CH <sub>4</sub> /kg VS <sup>(1)</sup>	% Methane <sup>(1)</sup>
Scrape Collection	1 X (2 kg VS/L)	16	0.190	67
Scrape Collection	2 X (4 kg VS/L)	13	0.155	63
Flush Collection	1 X (2 kg VS/L)	3	0.167	67
Flush Collection	2 X (4 kg VS/L)	4	0.222	69
	Overall Average	9	0.18	66

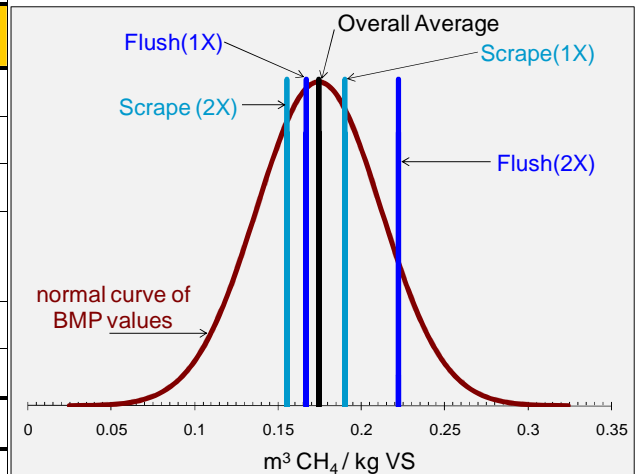
1. Data is from manure samples at two dairy farms in the Willamette Valley.

Literature BMP values (shown below) for dairy manure range from 0.126 m<sup>3</sup>CH<sub>4</sub>/kg VS to 0.243 m<sup>3</sup>CH<sub>4</sub>/kg VS and have a 14 value average of 0.175 m<sup>3</sup>CH<sub>4</sub>/kg VS. The results (0.155 to 0.222 m<sup>3</sup>CH<sub>4</sub>/kg VS) for these representative samples were generally in line with literature values and suggest

process optimization, such as loading rates tied to manure handling conditions, will control methane production.

Literature Source	Methane yield m <sup>3</sup> CH <sub>4</sub> / kg VS
Amon, 2007 <sup>(1)</sup>	0.126 – 0.166
Kishore, 2007	0.130
Ghaly, 2000 <sup>(2)</sup>	0.151 – 0.208
National Institute of Industrial Research, 2004 (Hashimoto)	0.200
Mashad, 2007	0.240
Labatut, 2008	0.243
<b>Willamette Valley (2009)</b>	<b>0.183</b>
<b>Overall Average<sup>(3)</sup></b>	<b>0.174</b>

**Figure 17 Comparison of Willamette Valley manure to literature methane yield values (EC Oregon, 2009)**



1. Impact of dairy cow diet was assessed for methane potential (Amon, 2007).
2. Assessed VS loading rate and AD temperature for dairy manure (Ghaly, 2000).
3. Average is based on Willamette Valley BMP results and 14 literature values.

\*Digestion trials were based on a homogenized sample from two collections on one day; actual methane yield for dairy manure will vary by collection, time of year, diet, or digester technology.

### Evaluation of Local Co-Substrates

A biogas plant located at a dairy farm has a lot of flexibility in choosing locally available co-digestion substrates to optimize biomethane yields and to provide for energy security. From a financial perspective, it is logical to transport co-digestion feedstocks low in moisture that are energy dense. Some examples of such substrates include potato chip waste, annual ryegrass straw (ARS), glycerin and FOG. To examine the impact on methane yields, samples for BMP assays were setup with manure collected by scrape collection and mixed with energy dense low moisture substrates. Mixtures with about 80% dairy manure, less than 20% ARS and 5% glycerin or FOG were prepared and tested in BMP assays. The results indicated a 17% addition of ARS can increase the methane potential by 30%. Adding a 5% mix of FOG or glycerin to the ARS/dairy manure blend can increase methane potential by 60-90% over dairy manure alone. Digestion trials were based in each case on a single sample from a single point in time; actual methane yield for each of these feedstocks may vary.

**Table 15 Co-digestion feedstock trials (EC Oregon, 2009)**

	Feedstock	% moisture of feedstock	% of mix	BMP (m <sup>3</sup> CH <sub>4</sub> / kg VS)
Individual Feedstock	Dairy Manure (Scrape)	89.5	100	0.172
	ARS	12.6	100	0.286
	FOG (Waste Grease)	4.2	100	0.572
	Glycerin	7.8	100	0.352
	Potato Chip Waste	19.8	100	0.508
	Poultry Manure	30.0	100	0.240
Mixture	Dairy Manure	89.5	83	0.226
	ARS	12.6	17	
	Dairy Manure	89.5	79	0.269
	ARS	12.6	16	
	Glycerin	7.8	5	
	Dairy Manure	89.5	79	0.319
	ARS	12.6	16	
	FOG	4.2	5	

**CO-DIGESTION FEEDSTOCKS NEAR GRANTS PASS AND MEDFORD METRO AREA**

**Corn Silage and Silage Leachate** - Corn silage and silage liquor are on farm feedstocks with good BMP values of 0.319 and 0.417 m<sup>3</sup> CH<sub>4</sub> / kg VS, respectively, though available in relatively small quantities. Good silage management seeks to minimize the amount of silage liquor (leachate and surplus waste) that is produced. As long as moisture is minimized, little leachate will be produced. Since this leachate likely already drains to the reception pit, collection of the silage liquor should be easy. Since the collectable amounts are likely low, neither the silage liquor nor the silage waste is anticipated to make a sizable impact on methane production under current handling methods.

**Dairy Manure** – Dairy manure is the most common agricultural digester feedstock in the United States. Most on farm digesters in Europe also use some percentage of livestock manure. Dairy manure is a good buffering agent for higher energy feedstocks. In a co-digestion scenario, manures will buffer pH, supply nutrients and provide consistent feedstock from a point-source. With a high moisture content and low methane yield, acquiring offsite dairy manure could prove to be cost prohibitive. Noble Dairy already has a substantial amount of dairy manure onsite that should provide appropriate buffering capacity for most co-digestion feedstock mixtures.

**Agricultural Residues** – A query of the USDA National Agricultural Statistics Service website for data on major crops grown in Jackson and Josephine counties suggests most agricultural crops (wheat, oats, barley, hay, and alfalfa) are grown as forage or food crops. However, wheat straw may be available as an agricultural residue that may not compete for feed. If so, wheat straw shows promise as a high energy co-digestion feedstock that could be ensiled with food processor residue to mitigate seasonal feedstock availability. The low moisture content and high energy density of wheat straw make it an attractive co-substrate for dairy manure, but there are some risks to straw being incompatible with some digesters. Particle size reduction will be required for more rapid degradation and to prevent mat formation within a digester. Digester systems containing thorough mixing are able to prevent most stratification. A preliminary estimate for the cost of harvesting and transporting straw less than 40 miles would be

approximately \$35 per ton; the \$10 per ton Biomass Tax Credit would be available to the producer or collector.

**FOG** - There are different qualities of fats, oils and greases (FOG), therefore competition for some sources exists. Recycled cooking oil (known as yellow grease) is currently coveted by companies producing biodiesel so its acquisition is unlikely. However, the screening of impurities from yellow grease creates a waste stream usable in digestion. Also, grease trap waste (GTW, aka brown grease) which is not suitable for biodiesel production is available from urban areas. Extrapolation of data supplied from a regional hauler approximates the combined total available GTW from Grants Pass, Ashland, Phoenix, and Medford urban areas at 5.7 tpd. Fats, oils and grease would be an excellent additive to a co-digestion biogas plant by significantly enhancing biogas output when used in small quantities.

**Municipal Food waste (MFW)** – While variable, a literature review determined that municipal food waste (MFW) is an excellent anaerobic digester feedstock with very good specific methane yield. Food waste quality and composition are greatly variable depending on source, region and collection method, but is significantly more biodegradable than other commonly used feedstocks. It also has relatively high macro- and micro-nutrient contents to facilitate healthy digester bacterial growth and enhance effluent fertilizer value. However, impurities (i.e., plastic, metal, glass) must be removed from the municipal food waste stream to prevent mechanical failure of facility components and produce marketable co-products. Collection logistics and contamination issues may be mitigated by tipping fees. Since it is not currently collected, MFW is seen as more of a long term possibility.

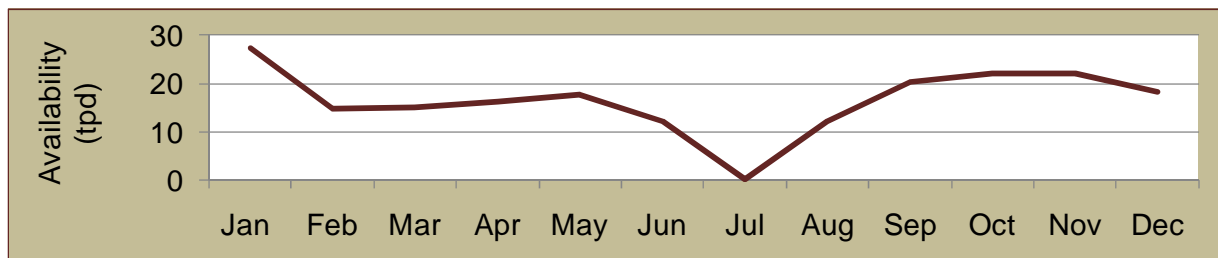
A recent thesis from University of Oregon (*Nelson, 2007*) estimated “large”, non-residential sources (restaurants, supermarkets, schools and hospitals) in the Eugene-Springfield area generate 17,870 tpy of MFW. Extrapolating the Eugene/Springfield (population 343,140) data on the basis of population with the Grants Pass-Medford area (population 225,000), would generate about 11,700 tpy of MFW. A voluntary commercial collection system in the Portland Metro area captures approximately 20% of the MFW generated. It is therefore assumed the amount of available MFW that can logistically be source-separated, collected and delivered is 2,340 tpy (6 tpd).

Digesting MFW, which would include some amount of animal by-product (ABP), raises issues related to public, animal and environmental health. According to a current European Commission Regulation (No 1774/2002), ABP are categorized (Category 1 = very high risk, Category 2 = high risk, and Category 3 = low risk). Category 1 materials include carcasses infected with bovine spongiform encephalopathy (BSE) or suspected of BSE infection, specified risk material (SRM) such as, skull, brain, eyes, vertebral column, spinal cord, tonsils, intestines, spleen and ileum. All Category 1 material is banned from AD. Category 3 materials include catering waste, food factory waste, supermarket waste, parts of slaughtered animals that are suitable for human consumption but are not intended for consumption due to commercial reasons; consists of parts of animals unfit for human consumption, but do not contain communicable diseases and didn't come from diseased carcasses. Category 2 materials are those not falling into the other categories. EU standard requires a hygenisation unit capable of holding Category 3 material at 70 °C (158 °F) for 60 minutes and Category 2 requires sterilization  $\geq 3$  bars,  $\geq 133$  °C,  $\geq 20$  minutes prior to AD. There are currently no rules or regulations in place in

Oregon specifically dealing with AD of ABP; this will likely change in the future. EC Oregon strongly recommends following EU guidelines concerning AD of ABP.

**Poultry Litter** - There is an egg laying operation with 320,000 chickens less than 40 miles away from Noble Dairy. Based on layer information from other Oregon farms, poultry litter consisting of chicken manure and typically wood shavings as bedding is collected at an estimated rate of 6,000 tpy (16 tpd). The long period of time between collections likely allows the manure to degrade on-site, decreasing its energy potential. Wood shavings are generally problematic in digesters since woody biomass is resistant to rapid anaerobic degradation. Though the use of an alternate bedding material along with more frequent collection would help to maximize VS, pretreatment in settling tanks would be required to remove and prevent grit and feathers from entering the digester. Despite the availability of poultry litter as a feedstock, the likelihood of wood based bedding makes it a less attractive co-digestion feedstock than other substrates.

**Food Processing Residue** - Food processing residue (typically fruit and vegetable residue) is available at various quantities and qualities (70-90% moisture). A seasonality assessment shows a peak of 27 tpd in January with a low in July of 0 tpd. The rest of the year the availability fluctuates between 12 and 22 tpd. Additional locally available suitable substrates exist, but their availability, transportation logistics as well as additional factors do not make these feedstocks as attractive those previously mentioned.



Ensiling is a way to mitigate seasonal fluctuations in processor waste quantity, but variations in quality will persist. Storing food processing waste with straw will preserve the nutritive value of these feedstocks with little to no loss of methane potential and provide for a guaranteed supply of consistent quality feedstock year-round. Ensiling is a well documented process that takes place in an anaerobic environment where naturally occurring bacteria produce lactic acid from carbohydrates, which lowers pH and prevents spoilage. In fact, the silage process largely mimics the first two steps of the AD process, hydrolysis and acidification - effectively acting as a pretreatment. Silage, along with the dairy manure, would buffer the digesters and allow for addition of moderate amounts of various other feedstocks as available. However, ensiling will increase biogas plant capital expenditures as well as operation and maintenance expenses.

### **CO-SUBSTRATE RECEPTION, PRETREATMENT, STORAGE**

If co-digestion feedstocks are utilized, some pretreatment may be necessary depending on the type of feedstock. Straws or silages may require particle size reduction. Other feedstocks, such as FOG may not require any specialized pretreatment equipment other than appropriate storage receptacles.

Particle size reduction enhances hydrolysis by increasing the available surface area. However, numerous studies have shown that the law of diminishing returns applies. The threshold particle size under which further reduction becomes unnecessary varies based on feedstock type, grinding method and site-specific energy economics, but is widely agreed to be above 1 mm (0.04 in).

Physical receiving equipment at the digester for offsite feedstock will be standard to material handling (i.e., hoppers, conveyors, and/or augers). A hammermill or grinder will likely be required to reduce remaining large substrate particles. Studies (Mshandete 2006, Sharma 1988) have shown that biogas production is inversely proportional to feedstock particle size, but with diminishing returns. Optimal particle size, and therefore grinder specifications, will be determined by the particular feedstock, digester design and vendor recommendations.

Liquid feedstocks can be collected into a receiving pit or dosing tank and then pumped into the digester. For dry feedstocks, the direct feeding system used in at least half of new energy crop biogas plants in Europe is a modified feed mixer, a common piece of equipment in the livestock feed industry. A feed mixer ensures a well mixed substrate that can be fed at a constant rate.

For grower biomass producer tax credit purposes, all material to be used as feedstock must be weighed, either at the time of collection or feeding. A weigh-scale incorporated into a receiving hopper or the feed mixer will accommodate all feedstock and allow for accurate feeding rates.

## **FARM FACTORS AND DAIRY MANURE QUALITY**

Multiple on farm factors can impact the quality of manure and subsequently impact methane yields as well.

### **Low Concentration of Total Solids**

Dairy manure is typically excreted at 12-15% TS. Any process water or rainwater incorporated into manure collection could drastically dilute the manure. Dilution of the manure may be incompatible with certain digester designs. For instance, low % solids have created crusting or foaming in a plug-flow digester. Even though a lower % solids is compatible with certain AD technologies, a low % solids is not recommended. Since significantly larger volumes of cold water will need to be heated to at least mesophilic temperatures for efficient methane yields, having excess quantities of water in the digester will lower the efficiency of methane production and revenue generated. Likely reasons for manure dilution are from the dairy process water, flush manure collection and the wet winters in Josephine County. Maintaining a high % TS for the manure may be challenging during Oregon's winter months. Nevertheless, rainwater and other water need to be minimized or prevented from co-mingling with manure.

Though technologies such as thickeners exist to increase solids content of slurries from flush collection, they are not recommended. If a thickener is used, VS will be lost resulting in a net loss in manure methane proportional to the solids capture rate of the thickener. Alternatively, scrape based collection captures the manure closer to an excreted state (high % TS). Therefore, scrape based collection is the preferred approach over flush collection. Similarly, a feasibility study on AD for Idaho dairy farms concluded that dairy manure requires a high solids content to be a viable energy producer; therefore flush collection would not be a viable biomethane approach (Mountain View Power, Inc.).

Automated scrape based manure collection systems exist with similar efficiencies and conveniences to flush based collection systems. Electric, programmable alley scrapers are touted as labor saving devices that are safe for cows lingering in the alleys. A hinged scraper blade is pulled down the alley on a cable or chain by a geared low-horsepower motor; the blades retract for the return trip. Increased scraping frequency may contribute to cleaner barns. Manure management related incentives, such as the USDA's NRCS Environmental Quality Incentives Program (EQIP) can provide capital cost share. Since the switch to scrape is recommended for more efficient digester operation and would be directly involved in collecting feedstock for renewable energy production, an automated scrape system may also qualify for Oregon's Business Energy Tax Credit (BETC).

### **Incompatible Dairy Bedding**

Common practices for dairy farms in the Willamette Valley include the use of straw, recycled paper or composted manure solids as bedding. Though wood shavings and sawdust are available in the area, they are not recommended for AD. Plug-flow digesters have experienced mat formation from wood shavings and clogging due to wood chips. Fortunately, when AD is combined with post-digester composting, virtually pathogen-free bedding is produced from the digestate solids.

## **Inhibition and Toxicity**

There have been reported instances where on farm chemicals have impacted the methane potential of anaerobic digesters. For example, an anti-freeze leak in a barn killed much of the digester bacteria when the tainted manure was included in the feedstock. Another incident involved sanitizing footbath added to the digester feedstock which also depleted the bacterial population.

To assess toxicity of chemicals commonly found on dairy farms researchers have done anaerobic toxicity batch assays. Inhibitory concentrations that caused a 50% decrease in methane production rate ( $IC_{50}$ ) were established for a wide array of chemicals commonly used on dairy farms. The most problematic chemicals found were quaternary ammonium chloride and a methanogen inhibitor feed additive (Rumensin). Both of these had an  $IC_{50}$  0.1 (v/v), whereas copper sulfate, a common hoof sanitizer, had an  $IC_{50}$  4.0 (v/v). Some other products, like surfactants, actually showed increases in methane production. Additional studies have shown when bacteria are repeatedly exposed to low doses of a compound the bacteria can acclimate to higher concentrations.

Since dairy manure has a strong buffering capacity, it is unlikely hydrated lime - a common drying agent for bedding - will raise the pH of the manure to a level incompatible with AD. However, certain technologies, such as fixed film digesters, may accumulate calcium precipitates and eventually clog if lime is routinely used.

Large spills or other ways of introducing a large quantity of farm based compounds into the digester may be problematic. Addition of co-digestion feedstocks might help dilute any potential farm based inhibitory compounds. As a precaution EC Oregon recommends storage of farm chemicals to limit spills into the reception pit area, as well as implementing a spill response and control plan.

## **Dairy Cow Diet**

It is important to note that diet of a cow directly impacts the lignin and crude protein in the cow manure. Increased crude protein increases methane yields, whereas increased lignin content lowers methane yields. Switching from a hay based diet to more of a summer based feed, such as clover grass, can increase methane yield as well. In an extreme case, the type of feed has been shown to impact dairy cow manure methane potentials by as much as 24%. Some AD systems have experienced foaming coinciding with dietary changes. EC Oregon is not recommending a change in current feeding practices, but noting that some seasonal differences in methane production from dairy manure are anticipated.

## **Performance Related Problems**

Compilations of case study data shows that some of the complaints owners have had with on farm digesters can be grouped into the following categories: selection of a design that was incompatible with manure harvesting, design not compatible with location, design operation and maintenance was more complex than necessary, digester was not large enough to process manure capacity, existing structures and equipment were not utilized to full potential, poor process control, maintenance was not followed and digester was not compatible with on farm practices.

In order to avoid these problems it is essential that the digester design fits a dairy's farming practice. Operation and maintenance performance data compatible with respective farming practices should dictate the technology selected rather than the lowest cost.

Specific items of concern for Noble Dairy include: 1) low % solids have created crusting or foaming in a plug-flow digester, 2) wood shavings have been known to form a mat within a plug-flow digester and 3) wood chips are known to clog a plug-flow digester.

## Appendices for Section 4

### SIMILAR FACILITY CASE STUDIES

#### Expected Gas Yields and Electrical Production

Case study information was assessed for US dairy farms that had anaerobic digesters with only dairy manure as sole feedstock. As long as a digester is designed to match dairy farm practices, manure handling is optimized and the digester is well maintained, it is possible to get values higher than the upper ranges. Conversely, a digester not matching the dairy farm needs, a poorly maintained digester, or inefficient manure collection will result in performance levels below the ranges shown.

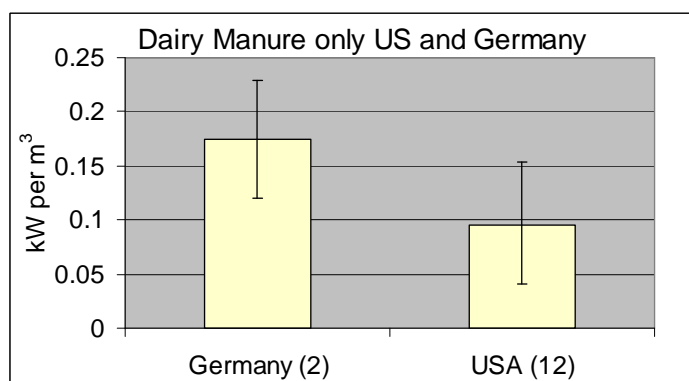
**Table 16 Case study summary table of dairy manure as sole feedstock**

	Average <sup>(1)</sup>	Expected performance range <sup>(1)</sup>	Number of case studies <sup>(1)</sup>
ft <sup>3</sup> biogas /day/cow	66	46 - 86	17
ft <sup>3</sup> CH <sub>4</sub> /day/ cow	33	25 - 40	13
kWh /day/ cow	2.6	2.0 - 3.3	18

1. Data from Kramer 2004, Kramer 2008, Lusk 1998, Wright 2003, Wright 2004, Topper 2008, Martin 2003, Martin 2005, Martin 2007, Walters 2007, and Sjoding 2005 was compiled by EC Oregon (2009).

#### Anaerobic Digestion: Europe (EU) and United States (US)

Directly comparing anaerobic digestion of dairy manure in the US to European data is difficult, because most biogas plants built in Europe practice co-digestion. In the US, even with manure as the sole feedstock, the process might not be optimized given a certain volume digester. True performance data is elusive; the installation and operation of a digester does not ensure capacity is being met. The installation of excess electrical capacity allows a biogas plant flexibility to optimize their system, by importing higher energy feedstock when available, without having to install additional digester capacity.

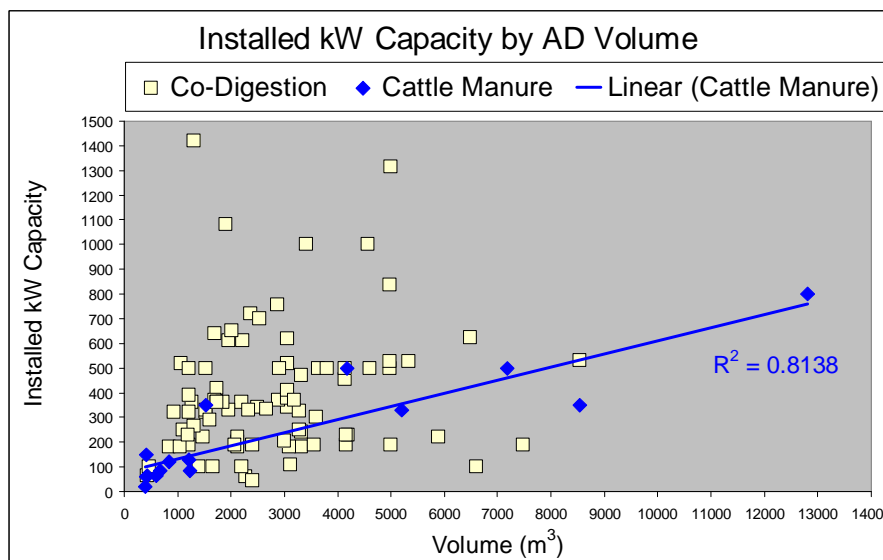


- X-Axis is biogas plant country with the number (n) of samples in parenthesis
- Y-axis = mean kW installed per m<sup>3</sup> of digester volume, and error bars represent minimum and maximum values.
- Mean (yellow bars), minimum (black error bars) and maximum (black error bars) kW per m<sup>3</sup> values were calculated for each country (Data compiled from Biogas-Nord 2008, Topper 2008, Lusk 1998 and Martin, 2005).

**Figure 18 Germany vs. United States kW per digester volume (EC Oregon, 2009)**

If co-digestion feedstocks are assessed for electrical potential by volume of digester, it is clear that the process is not optimized when only dairy manure is added to the digester. The installed electrical potential per digester volume of cattle manure was compared to co-digestion data where at least a portion of the co-digestion feedstock contains cattle manure. A regression

analysis for dairy manure as the sole feedstock showed a decent correlation ( $r^2 = 0.81$ ), indicating there is a strong correlation between digester volume and electrical capacity if only dairy manure is used. However, regression analysis of co-digestion feedstock failed to show any correlation ( $r^2 = 0.026$ ) between digester volume and electrical capacity. This is due to differences in energy density of regionally available feedstocks. This data clearly indicates that co-digestion has the potential to increase the electrical capacity of a given size digester by a magnitude up to 5 times greater than dairy manure alone.



- Chart of anaerobic digester volume ( $m^3$ ) by installed kW capacity.
- Blue diamonds represent cow manure as the sole feedstock.
- Blue line represents regression line for dairy manure as sole feedstock. Yellow squares represent co-digestion feedstocks.
- All data points were from either complete mix or plug-flow digesters

Compiled from Biogas-Nord 2008, Topper 2008, Lusk 1998 and Martin, 2005.

Figure 19 Installed kW by volume; EU and US data (EC Oregon, 2009)

If only dairy manure is used the return on investment would be less attractive since the potential for energy produced from dairy manure is much lower than energy dense feedstocks.

## ANCILLARY TECHNOLOGY OPTIONS

### Biogas to Electricity and Heat via Co-generation

If electricity is a desired end product of biomethane, the most common production method is a combined heat and power (CHP) unit, also known as co-generation. The unit is typically a stationary internal combustion engine and integrated generator specifically engineered to operate on biogas (or natural gas). Dozens of vendors worldwide, with a range of experience, provide biogas compatible CHP units with varying performance specifications. Implementation of CHP units at biogas plants is proven, straightforward and well documented; for this reason it will be summarized briefly.

The electricity generated has potential for use at the facility or sale to the utility. Multiple smaller CHP units would provide redundancy while situated at different locations within the facility to maximize waste heat depending on specific needs.

Ideally, the site surrounding the biogas plant would utilize some or all of the heat generated by the CHP engine. Electricity production with an internal combustion engine and generator is

approximately 40% efficient; recovery of thermal energy from a CHP unit can raise the overall efficiency to roughly 80%, improving the energy balance of the project. Engine jacket heat can be routed through a heat exchanger to produce hot water; exhaust heat can be routed through a heat exchanger to produce steam.

The resulting hot water is used to pre-heat incoming feedstock and maintain mesophilic (or thermophilic) temperatures in the digester vessels. Other possible applications for thermal energy carried by water include powering an adsorption or absorption chilling system and heating a building/space or greenhouse.

The best use for thermal energy depends on the nature and needs of co-located operations and neighboring facilities, if any. If no use for thermal energy can be developed on the project site, options other than CHP become more attractive (e.g., biogas upgrade for injection to natural gas pipeline).

### Nutrient Recovery Equipment

All macro- and micronutrients present in a feedstock will pass through the digester and be present in the digestate, a product well suited for *agronomic, horticultural, and silvicultural uses*. Nitrogen (N) in the digestate will be primarily in the form of soluble ammonia and thus present in the liquid after dewatering; whereas phosphorus (P), typically insoluble in compound form, will largely end up in the fiber fraction. The distribution ratios of N and P in the fiber and liquid fractions will depend on the solids capture rate of the dewatering equipment.

Types of dewatering equipment include rotary screen and roller press and/or - decanter centrifuge, belt press or screw press. Separator technologies, such as centrifuges and belt filter presses, are available with the potential to double the % TS captured compared to a screen separator. Digested solids have different characteristics than undigested manure solid and are generally considered easier to separate.

**Table 17 Solids capture percentage for separator technology**

Separator	% Capture
Screen Separator	20-30
Biolynk System	55-60
Centrifuge	75-90
Belt Filter Press	80-95

Since all the captured solids will have moisture associated with them, there is a net reduction in both macronutrients (N, P and K) and liquid going to the lagoon. As mentioned earlier, N will be mainly soluble and associated with the liquid fraction while P and K will be collected mainly with the fiber. The efficiency of the separator dictates the percent of the digestate balance to fiber storage and percent to the lagoon. A separator with a higher % TS capture will capture more fiber (P and K) with a percentage of the moisture (N) being retained in the captured fiber with both being diverted from the lagoon. The dry, fiber fraction of dewatered digestate can be used as a compost component, soil amendment, nursery planting media or animal bedding. An added benefit of the high solids capture rate is the lagoon will not require dredging as frequently. Whereas a separator with a low capture rate will allow fiber (hence more P and K) to flow to the

lagoon along with the centrate. Provided a market is established, an increase in recoverable fiber would allow for increased revenues from digestate solids.

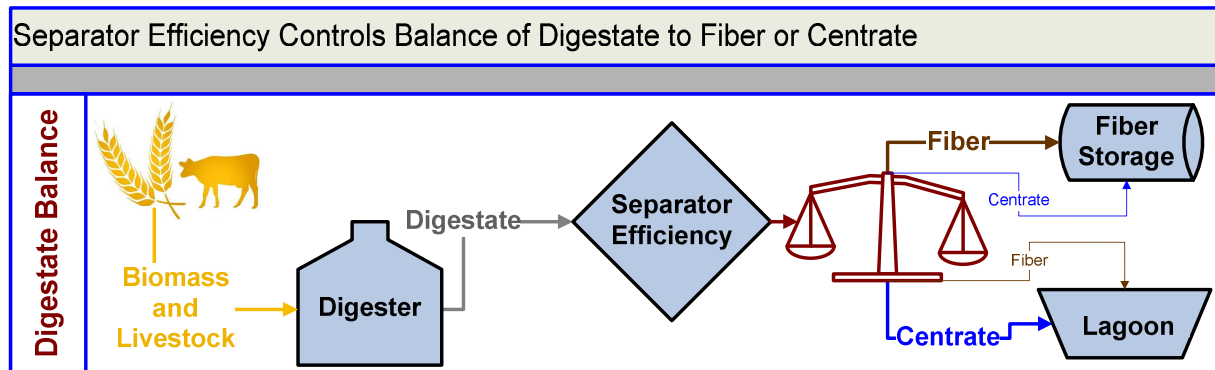


Figure 20 Separator efficiency and digestate balance (EC Oregon, 2009)

Depending on the biogas plant location and nutrient management plan, it may be possible to land apply the centrate directly to adjacent agricultural fields or store in a lagoon. Concentration is an option that will allow for storage, transport to remote growing areas and/or sale as liquid fertilizer. A market assessment would be required to determine whether and how much concentration would be beneficial.

Since the digestate solids will not include any plastic material nor any other unwanted byproducts, potential outlets for digestate solids would include organic recyclers, agricultural commodity haulers and annual ryegrass straw growers. The relatively dry fiber fraction of dewatered digestate can be used as compost component, soil amendment, nursery planting media or animal bedding. Although no formal opinion has yet been requested, Oregon Tilth believes digestate can be used in certified Organic crop production. Literature sources suggest the nationwide average prices for digestate composted solids are \$15 to \$25 per ton and fresh, uncomposted digestate solids are \$3 to \$6 per ton. Whether the increased revenue from composted digestate solids warrants the additional labor and space costs is a case-by-case farm decision. As more anaerobic digesters are built, the market for solids may become saturated. Therefore at this time conservative values for digestate as additional revenue are recommended.

#### PERMIT LIST

Oregon Department of Environmental Quality (DEQ) Air Quality Division will require an Air Contaminant Discharge Permit (ACDP) to install and operate any generator(s). The type of ACDP likely to be required ("Simple") has a 5 year duration, \$5,000 initiation fee and \$1,600-\$3,200 annual fee. A public notice and comment period is also part of the permit process. The DEQ has up to 120 days from when an ACDP application is deemed complete to issue a permit.

Oregon DEQ Water Quality Division will also require a biogas plant to have a Water Pollution Control Facility (WPCF) or National Pollution Discharge Elimination System (NPDES) permit in order to discharge digester effluent to a lagoon or as a land application. Noble Dairy currently has a NPDES as part of their CAFO permit and no additional permitting is expected. Application processing and annual fees for a new permit, if necessary, would amount to approximately \$9,000 and \$3,000, respectively.

A construction stormwater permit (1200-C) will also be required by Oregon DEQ if more than one acre of land is to be disturbed during construction (including access roads and on-site mined gravel source). The construction stormwater permit application must include an Erosion and Sediment Control Plan (ESCP) and requires a fee of \$795. Noble Dairy has a Standard Industrial Classification (SIC#) of 0214: dairy farm, and as such is exempt from the industrial stormwater permit (1200-Z) requirement.

According to Oregon DEQ, a biogas plant will require a solid waste permit prior to bringing in outside feedstocks if they are deemed “solid waste”. Solid waste is defined as “*useless and discarded*” material (ORS 340-093-0030.82) from the perspective of the generator, regardless of whether it is sold, given away for free or disposed of at a cost. By-product streams generated on-site and used as a feedstock for another process in the same facility – such as manure in a digester – would not be considered solid waste. ARS, for example, could be treated as solid waste by the definition above, but it is unclear if DEQ will take this position. DEQ is currently developing rules that will authorize “Beneficial Use Determinations” for certain solid waste materials which, when used in designated processes, do not create adverse impact to human health or environment – effectively short-cutting the need for a solid waste permit.

Oregon law requires state agencies to ensure that a permitted activity is consistent with local zoning districts, comprehensive plans and land use regulations. Any state-issued permit application must be accompanied by a land use compatibility statement (LUCS) signed by the local county authority. In all likelihood, an anaerobic digester will be considered an “allowed use” as ancillary equipment for an existing dairy. In addition, local building codes will need to be followed. If a DEQ solid waste permit is required for a facility, then local planning departments usually consider the site to be a solid waste disposal site for the purpose of reviewing a LUCS. However, it is possible that the case can be made that the facility’s main purpose is energy generation, if this is beneficial.

## **RENEWABLE ENERGY INCENTIVES**

### **Renewable Energy Certificates (RECs)**

Renewable Energy Certificates (RECs) are also commonly known as Green Tags, Renewable Energy Credits, or Tradable Renewable Certificates (TRCs). One REC represents the environmental and social benefits from one megawatt-hour (MWh) of electricity generated from an eligible source fed to the grid. While this is the generally accepted definition, variations do occur depending on the certifying agency.

A dairy manure based biogas plant generating renewable electricity will qualify for REC certification. Actual certification will require knowledge of project specific variables which include, but are not limited to: site location, interconnection utility, power purchase agreement terms, feedstocks utilized, electric generation technology, and facility commissioning date. Reliable reference price indexes for RECs in the Compliance and Voluntary Market are not available. However, EC Oregon recently negotiated two Voluntary Market REC contracts for a biomass based project in the Willamette Valley where opening offers ranged from \$4.00 to \$8.00 a tag.

## **Carbon Offsets**

The potential exists for an anaerobic digester project to earn carbon offsets from offsetting lagoon emissions and other carbon-equivalent sources. The Chicago Climate Exchange's recent pricing history indicates a high of \$7.40 per metric ton CO<sub>2</sub> (June, 2008) and a low of \$1.10 (November, 2008). The determination process is complex, time consuming and depends on project specific variables such as, but not limited to: project site, project boundary definition, current regulatory environment, technological and/or financial barriers, additionality and other protocol specific requirements.

## **Biomass Producer Tax Credit**

The producer or collector of biomass is eligible through 2012 for a tax credit of \$5.00 per wet ton of animal manure and \$10.00 per green ton for biomass produced on the farm, such as straw or grass. Collection of offsite biomass may also be eligible at the rate of \$10.00 per green ton.

## **Oregon Business Energy Tax Credit (BETC)**

Investments made in Oregon for energy conservation, renewable energy, recycling, sustainable buildings, and alternative fuel and hybrid vehicle projects may qualify for Oregon's Business Energy Tax Credit (BETC).

For renewable energy projects, a tax credit of 50% of the qualified project costs is available. The tax credit can be utilized over a five year period, at 10% of project costs per year. Any unused credit can be carried forward for an additional three years if necessary. Additionally, the tax credit has the added flexibility of a pass-through option. The whole value or portion of the tax credit can be transferred to a pass-through partner in exchange for a lump sum payment at the net present value (currently 33.5%) of the tax credit as determined by the Oregon Department of Energy (DOE).

Anaerobic digestion is a recognized eligible technology and the qualified costs include all costs directly related to the project including equipment costs, engineering and design fees, materials, supplies and installation costs. Loan fees and permit costs also may be claimed. Replacing equipment at the end of its useful life, equipment required to meet codes or other government regulations, and operation and maintenance costs are not eligible.

## **Renewable Production Tax Credit (PTC)**

The federal Renewable Electricity Production Tax Credit (PTC) is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources. Anaerobic digestion, as proposed in this study, is considered "open loop biomass" and as such is eligible for \$0.01/kWh. Whereas corn or grass silage grown solely for use in a biogas plant would qualify as "closed loop biomass" and be eligible for a \$.021/kWh tax credit.

Since enacted the PTC has been renewed multiple times, typically for 1-2 year extensions. Currently, the "open loop biomass" clause expires on Dec 31, 2013. To claim this credit, facilities must be "in service", as defined by IRS tax code, by that date. Facilities that qualify can claim the credit for 10 years following the in service date.

## **Net Metering**

Current Oregon Administrative Rules require PacifiCorp to allow “net metering” for non-residential customers with small renewable energy generation facilities (2 MW or less); larger generators may be considered on a negotiated basis. Net-metering allows for any net excess generation (generation over facility consumption) to be credited to the consumer’s account. When the consumer produces less than the demand, they draw from the credit retained. At the end of the 12 month period any residual credit is forfeited by the consumer – therefore a net-metering scenario only makes sense if production is equal to or less than on-site demand. Net metering is also eligible for RECs.

## **Funding Opportunities**

The USDA Rural Energy for America Program (REAP), formerly known as Section 9006, is undergoing revision per the 2008 Farm Bill. As new rules are released, the following information may change slightly. Anaerobic digestion is an eligible technology under REAP, which has grant and loan guarantee components; both require that the applicant own and control operations of the project and be a rural small business or agricultural producer. Grants, which require the applicant show a “demonstrable financial need” for assistance, are available for 25% of eligible project costs, up to \$500k. If lender so requires, they may also apply with the applicant for a loan guarantee for a maximum of \$25M, or 75% of project costs. A grant/loan guarantee combination request may increase the odds of a grant award.

The Oregon DOE administers the Small-Scale Energy Loan Program (SELP), which is funded by bond sales. Loans for up to 50% of project costs are available with 10-15% owner equity. Technical eligibility criteria for SELP are largely the same as for the Oregon BETC, therefore an on farm digester would qualify. There are additional financial performance measures that are considered; a pro-forma financial analysis and business plan are required for application.

The American Recovery and Reinvestment Act of 2009 (also known as the stimulus bill) authorized the U.S. Department of Treasury to implement a renewable energy grant program. Essentially, projects that are eligible for the renewable PTC (see above) can receive an up-front grant for 30% of eligible project costs instead of the tax credit. Other non-governmental organizations, such as Energy Trust of Oregon (ETO) or Bonneville Environmental Foundation (BEF), may have the means to support the development of anaerobic digestion projects on a case-by-case basis.

The 2008 Farm Bill established a new program known as Biomass Crop Assistance Program (BCAP) to help farmers convert cropland to dedicated biomass and bioenergy crops. The tentative guidelines laid out in the bill cover up to 75% of conversion costs (including costs of seeds and stocks for perennials, crop planting, “lost opportunity costs” and in some cases site preparation) while establishing biomass/bioenergy crops. Matching cost-share payments for harvesting, storing and transporting to a bioenergy facility are available up to \$45 per dry ton. Some current commodity crops, noxious plants and invasive weeds are not eligible for the program. If the BCAP were implemented as stated in the 2008 Farm Bill, annual appropriations of \$15,000,000 would be available through 2012.

The Farm Storage Facility Loan (FSFL) program was revised as part of the 2008 Farm Bill. The program provides low interest loans up to \$500,000 for farm storage and handling of certain

commodity crops and renewable biomass. The loan rate is based off the rate at which the Commodity Credit Corporation borrows from the Treasury Department. Rates during September 2009 were 3.250%, 3.625% 4.000% on loans with 7, 10 and 12 year terms respectively.

## **Appendices for Section 5**

### **BASE CASE SCENARIO FINANCIAL MODEL – SUMMARIES AND PRO FORMA Complete Mix Digester with Co-digestion Feedstocks at Noble Dairy**

**Jerry Noble**  
Base Case

**AD Financial Feasibility Model v2.3**

**Confidential!**

**Jerry Noble - Base Case**

AD: 135.4 Wet Tons/Day, 14.8 VS Tons/Day, 5.9 MCF/Hour Methane at 95.7% Capacity VS Basis  
CHP: Generating 616 kWh, 5,245,790 Annual kWh at 100.3% Capacity

RNG: 0 MCF/Hour

Financial: Pre-Tax ROI = 21+, Pre-Tax ROE = 1.6, NPV = \$-622,621 at 5% disc, IRR = 1.9%

Version: 10/30/2009

Developed by:



**Proprietary Property**  
of

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# Legend

Legend	Notes
<a href="#">Nav</a>	
<b>Static Text Labels</b>	
<p>The Static Text Labels show up in the following formats and should not be changed.</p>	
<h2>Tab Name</h2>	Name for tab
<h3>Section Heading</h3>	Heading for main sections
<h4>Section Sub Heading</h4>	Heading for sub sections
Item label	Label for items
Item label for item with <b>special emphasis</b>	Label for items which warrant emphasis
<b>Confidential!</b>	Label for items which warrant special consideration
<p>Notes:</p> <div style="border: 1px solid black; padding: 5px; min-height: 50px;">           Notes and instructions for use of the model will appear here.         </div>	Notes, comments and instructions pertaining to the use of the model. These note boxes can be collapsed or expanded as needed by clicking the "+" or "-" sign at the far left.
Notes and Comments	Notes and comments pertaining to calculations and the use of values. Additional notes provide guidance to acceptable input values.
<b>Input Variables</b>	
<p>The Input Variables show up in the following formats. These inputs are used in calculations and formula drive calculations. Enter and adjust these input variable to model out the desired scenario. It is recommended to document the basis for these variables in the notes fields provided.</p>	
<h2>Tab Name - Input Variable</h2>	Variable driven Name for tab
<h3>Section Heading - Input Variable</h3>	Variable driven heading for main sections
<h4>Section Sub Heading - Input Variable</h4>	Variable driven heading for sub sections
Input Variable	Variable driven label for items
<div style="border: 1px solid black; padding: 2px;">             Choice 1              Choice 2              Choice 3           </div>	List driven variable selection for items
Input Variable - Notes and Comments	Notes and Comments for Input Variables

### Calculations and Formula Driven Labels

Calculations and Formula Driven Labels show up in the following formats. Do not change these calculations.

### Section Heading - Formula Driven

Formula driven heading for main sections

### Section Sub Heading - Formula Driven

Formula driven heading for sub sections

Item label - Formula Driven

Formula driven label for items

1,000

Calculation driven value

2,000,000

Calculation driven total value

\$ 12,345

Calculated value is used on other tab(s) referred to in the notes. The background color mirrors the tabs they represent.

98%

Calculated value which is in an acceptable range

113%

Calculated value which may be out of an acceptable range

Look up value

Input variables which are driven by a lookup table

Formula driven notes and comments

Notes and comments which are formula driven

### Insert Zone

The Insert Zone labeled as "InsZone" allows for the inserting additional rows while keeping the integrity of formulas intact. To use this feature, right click on the row number which contains the InsZone and select Insert. Multiple rows can be highlighted and added at once as long as the selection begins with the row which contains the InsZone.

Value for item 1	123.00
Value for item A	456.00
InsZone	
	579.00

Right click on this row's reference number to insert additional rows

### Navigation

Navigation links are provided to quickly go to the Navigation Switch Board or another tab. Click on the Navigation link to go to the tab referenced. These links show up in the following formats.

Nav

Clicking the Nav link goes to the **Navigation** tab  
Navigation link background colors mirror the tabs they represent

GoTo Item label - Formula Driven

Clicking the GoTo link goes to the tab with the specified item

[www.ECOregon.com](http://www.ECOregon.com)

Clicking the link goes to the specified web site

[Dean@ECOregon.com](mailto:Dean@ECOregon.com)

Clicking the link starts a new email in the default email application addressed to the referred to recipient

## Client Parameters

### EC Oregon - AD Financial Feasibility Model v2.3

#### Jerry Noble - Base Case

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Scenario: AD: 135.4 Wet Tons/Day, 14.8 VS Tons/Day, 5.9 MCF/Hour Methane at 95.7% Capacity VS Basis

CHP: Generating 616 kWh, 5,245,790 Annual kWh at 100.3% Capacity

RNG: 0 MCF/Hour

Financial: Pre-Tax ROI = 21+, Pre-Tax ROE = 1.6, NPV = \$-622,621 at 5% disc, IRR = 1.9%

Version: 10/30/2009

Nav

Client, Project and Scenario Version		Units	Value	Notes
Client Name			Jerry Noble	
Scenario Name			Base Case	
Project Start	Date		1/1/2010	Assumed not until 2010 (DV 6/4/2009) The Project Start Date should coincide with the first financial transaction. For example, the first loan draw or investor contribution.
Scenario Version	Date		10/30/2009	Input last update

Clients Cost of Energy		Units	Value	Notes
Clients Cost for Conventional Electric	US \$ / kWh	\$	0.0657	Based on PGE schedule 32
Clients Cost for Conventional Natural Gas	US \$ / Therm	\$	2.2610	\$2.08/ gallon of propane X 1.087 gallons / therm as of 10/18/2009; <a href="http://tonto.eia.doe.gov/oog/info/tw ip/tw ip.asp#">http://tonto.eia.doe.gov/oog/info/tw ip/tw ip.asp#</a>

Clients Tax Rate and Rate of Inflation		Units	Value	Notes
Effective Federal Tax Rate	Percent		32.0%	Unknown - Not Provided
Effective Oregon Tax Rate	Percent		9.0%	Unknown - Not Provided
Rate of Inflation	Percent		3.0%	

## Manure Collection

EC Oregon - AD Financial Feasibility Model v2.3

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### Manure Source

Herd Notes:

Livestock Type	Livestock	Average	Total	Manure		Notes
		Weight	Weight	Manure	Manure	
	Count	Pounds	Pounds	Animal Units	Pounds / Day / Animal Unit	Pounds / Day
Lactating Cows	640	1,300	832,000	832	102.0	84,864
Dry Cows	80	1,400	112,000	112	57.0	6,384
heifers	350	750	262,500	263	57.0	14,963
calves	50	600	30,000	30	76.7	2,301
Bedding	-	-	-	-	-	10,621
InsZone						
<b>Total</b>	<b>1,120</b>			<b>1,237</b>		<b>119,133</b>

### Manure Source Summary

	Units	Value	
Manure	Pounds / Day	119,133	
Manure	Pounds / Year	43,483,381	
Manure	US Tons / Year	21,742	
Manure	US Tons / day	54.26	as excreted

### loss due to grazing and flush

Grazing loss

	Units	Value	Notes
Manure	US Tons / Year	(8,697)	Accounts for grazing , and loss of collectable manure at a rate of 40% annually, cow s
Collectable manure	US Tons / Year	13,045	35.739765

Flush Water Remaining After some thickening

	Units	Value	Notes
Tons / Year	US Tons / Year	26,726	flushed thickened from 1.5% to TS on feedstock tab (volume calculated from excreted).

### Totals

	Units	Value	Notes
Manure	US Tons / Year	13,045	
Flush Water after thickening	US Tons / Year	26,726	
InsZone			
<b>Total</b>	<b>US Tons / Year</b>	<b>39,770</b>	Value is used on the Feedstock tab Value is rounded to the nearest ten

**Feedstock Matrix**

**EC Oregon - AD Financial Feasibility Model v2.3**  
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Characteristics	Units	Flushed/Thickened Manure		Dilution Water		Amy's Kitchen		FOG / GTW		
		Feedstock 1	Notes	Feedstock 2	Notes	Feedstock 3	Notes	Feedstock 4	Notes	
Feedstock Comments										
N (as is basis)	Percent	0.25%	From lab: 11/20/2008	0.00%		0.00%		0.00%		
P (as is basis)	Percent	0.00%	Unknown	0.00%		0.00%		0.00%		
Total Solids (as is basis)	Percent	4.1%	thickening range of w/wt - 6-8%	0.0%		18.0%	calculated per waste description, Okara and DAF cake mainly at 20% TS	30.0%	Food Quality Lab results	
Volatile Solids of Total Solids	Percent	59.5%	Literature value (Reij, 2008), minus 15% loss due to thickening	0.0%		93.0%	calculated per waste description, Okara and DAF cake	90.0%	Food Quality Lab results	
Methane Yield	m <sup>3</sup> CH <sub>4</sub> / kg VS	0.190	Average from fit values and lab results	-		0.336	Average Estimated from CropGen Fruit&Vegetable Database	0.572	WoodsEnd Lab results	
<b>Availability</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Feedstock Available	US Tons / Year	49,403		39,770	Value comes from the Manure tab	-	2,760	assumes Amy's Kitchen onion waste, DAF CAKE and Okara	624	total for area estimated at 5.7 tpd, assume 30% capture
AD Volatile Solids Capacity	US Tons / Day	14.76		2.66		1.27		0.46		
AD Volatile Solids Capacity	US Tons / Year	5,385		970		462		169		
<b>Utilization</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Digester Volatile Solids Capacity	US Tons / Day	15.43	Value is calculated on the AD tab							
Feedstock Volatile Solids Utilization	US Tons / Day	14.76		2.66		1.27		0.46		
Volatile Solids Variance	US Tons	(0.67)								
Digester Operating Capacity on a Volatile Solids Basis	Percent	95.7%	Value is used on the AD tab	17.2%	0.0%	8.2%		3.0%		
Feedstock Utilized on a Volatile Solids Basis	Percent	100.0%		18.0%	0.0%	8.6%		3.1%		
Feedstock Utilization	US Tons / Day	135.4		109.0		7.6		1.7		
Feedstock Utilization	US Tons / Year	49,403		39,770		2,760		624		
Utilized Feedstocks on a US Ton Basis	Percent	100.0%		80.5%	0.0%	5.6%		1.3%		
Total Solids (as is basis)	Percent	12.9%	Weighted average	4.1%	0.0%	18.0%		30.0%		
Volatile Solids of Total Solids	Percent	84.3%	Weighted average	59.5%	0.0%	93.0%		90.0%		
<b>Methane Yield</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Weighted Average Methane Yield	m <sup>3</sup> CH <sub>4</sub> / kg VS	0.299	Weighted average	0.180		0.336		0.572		
Methane per Volatile Solids	MCF / US Ton			5.77		10.76		18.33		
Methane Production	MCF / Day	141.5	Value is used on the AD tab	13.34		13.67		8.43		
Methane Production	MCF / Hour	5.9	Value is used on the AD tab	0.64		0.57		0.35		
Methane Production	Percent	100.0%		10.8%	0.0%	9.7%		6.0%		
<b>Closed-Loop Biomass</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Closed-Loop Biomass (PTC)	Yes / No			No		No		No		
Methane Yield from Closed-Loop Biomass	Percent	0.0%		0.0%		0.0%		0.0%		
<b>Digestate Volume</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Destruction Rate of Volatile Solids	Percent			40%	Burke 2001	0%	Industry Average	70%	Industry Average	
Bogas	US Tons / Day	9.6		1.1	Methane and CO2	-	Methane and CO2	0.9	Methane and CO2	
Digestate	US Tons / Day	125.8	Value is used on the Nutrients tab	108.0		-	6.7	1.3		
Total Solids in Digestate	Percent	6.3%	Weighted average	3.15%		0.00%	7.12%	7.53%		
Digestate Dry Solids	US Tons / Day	7.9	Value is used on the Nutrients tab	3.41		-	0.48	0.10		
Digestate Liquid	US Tons / Day	117.9	Value is used on the Nutrients tab	104.57		-	6.22	1.19		
<b>Nitrogen &amp; Phosphorus Volumes</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
N	US Tons / Day	0.3	Value is used on the Nutrients tab	0.28		-	-	-		
N	US Tons / Year	103.4	Value is used on the Nutrients tab	103.40		-	-	-		
P	US Tons / Day	-	Value is used on the Nutrients tab	-		-	-	-		
P	US Tons / Year	-	Value is used on the Nutrients tab	-		-	-	-		
<b>Methane Equivalent Value (FYI Purposes Only)</b>	<b>Units</b>	<b>Totals</b>	<b>Notes</b>							
Clients Cost of Natural Gas	US \$ / Million BTU	\$ 22.61	Value is set on the Client tab.							
Value of Methane	US \$ / Day	\$ 3,199		\$ 347		\$ 309		\$ 191		
Value of Methane	US \$ / US Ton	\$ 526		\$ 3.18		\$ 40.74		\$ 111.87		



**Feedstock Matrix**

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Characteristics	Units	
Feedstock Comments		
N (as is basis)	Percent	
P (as is basis)	Percent	
Total Solids (as is basis)	Percent	
Volatile Solids of Total Solids	Percent	
Methane Yield	m <sup>3</sup> CH <sub>4</sub> / kg VS	

Availability	Units	Totals	Notes
Feedstock Available	US Tons / Year	49,403	
AD Volatile Solids Capacity	US Tons / Day	14.76	
AD Volatile Solids Capacity	US Tons / Year	5,385	

Utilization	Units	Totals	Notes
Digester Volatile Solids Capacity	US Tons / Day	15.43	Value is calculated on the AD tab
Feedstock Volatile Solids Utilization	US Tons / Day	14.76	
Volatile Solids Variance	US Tons	(0.67)	
Digester Operating Capacity on a Volatile Solids Basis	Percent	95.7%	Value is used on the AD tab
Feedstock Utilized on a Volatile Solids Basis	Percent	100.0%	
Feedstock Utilization	US Tons / Day	135.4	
Feedstock Utilization	US Tons / Year	49,403	
Utilized Feedstock's on a US Ton Basis	Percent	100.0%	
Total Solids (as is basis)	Percent	12.9%	Weighted average
Volatile Solids of Total Solids	Percent	84.3%	Weighted average

Methane Yield	Units	Totals	Notes
Weighted Average Methane Yield	m <sup>3</sup> CH <sub>4</sub> / kg VS	0.299	Weighted average
Methane per Volatile Solids	MCF / US Ton	9.68	
Methane Production	MCF / Day	67.34	Value is used on the AD tab
Methane Production	MCF / Hour	2.81	Value is used on the AD tab
Methane Production	Percent	100.0%	

Closed-Loop Biomass	Units	Totals	Notes
Closed-Loop Biomass (PTC)	Yes / No	No	
Methane Yield from Closed-Loop Biomass	Percent	0.0%	

Digestate Volume	Units	Totals	Notes
Destruction Rate of Volatile Solids	Percent	70%	
Biogas	US Tons / Day	9.6	
Digestate	US Tons / Day	125.8	Value is used on the Nutrients tab
Total Solids in Digestate	Percent	6.3%	Weighted average
Digestate Dry Solids	US Tons / Day	7.9	Value is used on the Nutrients tab
Digestate Liquid	US Tons / Day	117.9	Value is used on the Nutrients tab

Nitrogen & Phosphorus Volumes	Units	Totals	Notes
N	US Tons / Day	0.3	Value is used on the Nutrients tab
N	US Tons / Year	103.4	Value is used on the Nutrients tab
P	US Tons / Day	-	Value is used on the Nutrients tab
P	US Tons / Year	-	Value is used on the Nutrients tab

Methane Equivalent Value (FYI Purposes Only)	Units	Totals	Notes
Clients Cost of Natural Gas	US \$ / Million BTU	\$ 22.61	Value is set on the Client tab.
Value of Methane	US \$ / Day	\$ 3,199	
Value of Methane	US \$ / US Ton	\$ 526	

Wheat Straw	Sabroso	Associated Fruit Company
Feedstock 6	Feedstock 6	Feedstock 7
Notes	Notes	Notes
Could be ensiled to mitigate seasonality	Could be ensiled to mitigate seasonality	
0.00%	0.00%	0.00%
0.00%	0.00%	0.00%
93.0%	62.5%	16.0%
Zhang 2007	assumes pomace for fruit juice processing (pomace moisture content 37.5%)	usda national nutrient database
91.0%	97.0%	97.0%
Zhang 2007	average per USDA national Nutrient Database	usda national nutrient database
0.302	0.336	0.336
Tong et al. 1990	Average Estimated from CropGen Fruit&Vegetable Database	Average Estimated from CropGen Fruit&Vegetable Database

Availability	Units	Totals	Notes
Feedstock Available	US Tons / Year	3,000	Klamath county has more than Jackson and Josephine county; note only need 750 for ensiling to 30% due to pomace
AD Volatile Solids Capacity	US Tons / Day	1,643	8-10 tpd for 6 months
AD Volatile Solids Capacity	US Tons / Year	1,606	JR - 8.4 to 12 tpd mid August through mid Jan - Assumes Pear Waste - <a href="http://www.nw.specialtyfoods.org/member.php?co_name=152">http://www.nw.specialtyfoods.org/member.php?co_name=152</a>

Utilization	Units	Totals	Notes
Digester Volatile Solids Capacity	US Tons / Day	6.96	
Feedstock Volatile Solids Utilization	US Tons / Day	2.73	
Volatile Solids Variance	US Tons	0.68	
Digester Operating Capacity on a Volatile Solids Basis	Percent	45.1%	17.7%
Feedstock Utilized on a Volatile Solids Basis	Percent	47.2%	18.5%
Feedstock Utilization	US Tons / Day	8.2	4.5
Feedstock Utilization	US Tons / Year	3,000	1,643
Utilized Feedstock's on a US Ton Basis	Percent	6.1%	3.3%
Total Solids (as is basis)	Percent	93.0%	16.0%
Volatile Solids of Total Solids	Percent	91.0%	97.0%

Methane Yield	Units	Totals	Notes
Weighted Average Methane Yield	m <sup>3</sup> CH <sub>4</sub> / kg VS	0.302	
Methane per Volatile Solids	MCF / US Ton	9.68	
Methane Production	MCF / Day	67.34	
Methane Production	MCF / Hour	2.81	
Methane Production	Percent	47.6%	

Closed-Loop Biomass	Units	Totals	Notes
Closed-Loop Biomass (PTC)	Yes / No	No	
Methane Yield from Closed-Loop Biomass	Percent	0.0%	

Digestate Volume	Units	Totals	Notes
Destruction Rate of Volatile Solids	Percent	70%	
Biogas	US Tons / Day	4.9	
Digestate	US Tons / Day	125.8	Value is used on the Nutrients tab
Total Solids in Digestate	Percent	62.83%	Weighted average
Digestate Dry Solids	US Tons / Day	7.9	Value is used on the Nutrients tab
Digestate Liquid	US Tons / Day	0.58	

Nitrogen & Phosphorus Volumes	Units	Totals	Notes
N	US Tons / Day	-	
N	US Tons / Year	-	
P	US Tons / Day	-	
P	US Tons / Year	-	

Methane Equivalent Value (FYI Purposes Only)	Units	Totals	Notes
Clients Cost of Natural Gas	US \$ / Million BTU	\$ 22.61	Value is set on the Client tab.
Value of Methane	US \$ / Day	\$ 1,523	
Value of Methane	US \$ / US Ton	\$ 185.13	

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Characteristics			Units	Totals	Notes	Flushed/Thickened Manure Feedstock 1	Notes	Dilution Water Feedstock 2	Notes	Arny's Kitchen Feedstock 3	Notes	FOG / GTW Feedstock 4	Notes
Feedstock Revenue			Units	Totals	Notes								
InpZone			US \$ / US Ton			\$ -		\$ -		\$ -		\$ -	
	Feedstock Revenue	US \$ / US Ton	\$ -	Weighted average		\$ -		\$ -		\$ -		\$ -	
	Feedstock Revenue	US \$ / Day	\$ -			\$ -		\$ -		\$ -		\$ -	
	Feedstock Revenue	US \$ / Year	\$ -	Value is used on the Op_Sum tab		\$ -		\$ -		\$ -		\$ -	
Direct Expenses			Units	Totals	Notes								
InpZone			US \$ / US Ton			\$ -		\$ -		\$ -		\$ -	
	Feedstock Direct Expense	US \$ / US Ton	\$ 2.13	Weighted average		\$ -		\$ -		\$ -		\$ -	
	Feedstock Direct Expense	US \$ / Day	\$ 288			\$ -		\$ -		\$ -		\$ -	
	Feedstock Direct Expense	US \$ / Year	\$ 105,000	Value is used on the Op_Sum tab		\$ -		\$ -		\$ -		\$ -	
Opportunity Costs			Units	Totals	Notes								
InpZone			US \$ / US Ton			\$ -		\$ -		\$ -		\$ -	
	Feedstock Opportunity Cost	US \$ / US Ton	\$ -	Weighted average		\$ -		\$ -		\$ -		\$ -	
	Feedstock Opportunity Cost	US \$ / Day	\$ -			\$ -		\$ -		\$ -		\$ -	
	Feedstock Opportunity Cost	US \$ / Year	\$ -	Value is used on the Op_Sum tab		\$ -		\$ -		\$ -		\$ -	
Avoided Expenses			Units	Totals	Notes								
InpZone			US \$ / US Ton			\$ -		\$ -		\$ -		\$ -	
	Feedstock Avoided Expense	US \$ / US Ton	\$ -	Weighted average		\$ -		\$ -		\$ -		\$ -	
	Feedstock Avoided Expense	US \$ / Day	\$ -			\$ -		\$ -		\$ -		\$ -	
	Feedstock Avoided Expense	US \$ / Year	\$ -	Value is used on the Op_Sum tab		\$ -		\$ -		\$ -		\$ -	
Oregon Biomass Tax Credits			Units	Totals	Notes								
Oregon Biomass Tax Credit Effective Dates 2007 to 2012					Value set on Parameters tab								
OR Biomass Tax Credit Ag Crops			US \$ / US Ton		\$10 / Wet Ton	\$ -		\$ -		\$ -		\$ -	
OR Biomass Tax Credit Manure			US \$ / US Ton		\$5 / Wet Ton	\$ 5.00		\$ -		\$ -		\$ -	
OR Biomass Tax Credit Waste Oil & Grease			US \$ / US Ton		\$0.10 / Gallon	\$ -		\$ -		\$ -		\$ -	
InpZone			US \$ / US Ton			\$ 5.00		\$ -		\$ -		\$ -	
	Feedstock Tax Credit	US \$ / US Ton	\$ 4.03	Weighted average		\$ 5.00		\$ -		\$ -		\$ -	
	Feedstock Tax Credit	US \$ / Day	\$ 545			\$ 545		\$ -		\$ -		\$ -	
	Feedstock Tax Credit	US \$ / Year	\$ 198,850	Value is used on the Tax_Sum tab		\$ 198,850		\$ -		\$ -		\$ -	
Feedstock Net Expenses (FY Purposes Only)			Units	Totals	Notes								
InpZone			US \$ / US Ton			\$ 5.00		\$ -		\$ -		\$ -	
	Feedstock Net Expense	US \$ / US Ton	\$ 1.90	Weighted average		\$ 5.00		\$ -		\$ -		\$ -	
	Feedstock Net Expense	US \$ / Day	\$ 257			\$ 545		\$ -		\$ -		\$ -	
	Feedstock Net Expense	US \$ / Year	\$ 93,850			\$ 198,850		\$ -		\$ -		\$ -	



## Feedstock Evaluation

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NAV

Metric	Units	Totals	Flushed/Thickened Manure	Dilution Water	Amy's Kitchen	FOG / GTW	Wheat Straw	Sabroso	Associated Fruit Company
Feedstock Utilization	US Tons / Year	49,403	39,770	-	2,760	624	3,000	1,643	1,606
Utilized Feedstock on a AD Operating Capacity Basis	Percent	95.7%	17.2%	0.0%	8.2%	3.0%	45.1%	17.7%	4.4%
Methane Yield	Percent	100.0%	10.8%	0.0%	9.7%	6.0%	47.6%	20.8%	5.2%
Value as Methane (FYI)	US \$ / US Ton		\$ 3.18	\$ -	\$ 40.74	\$ 111.87	\$ 185.13	\$ 147.55	\$ 37.77
<b>Feedstock Net Income / US Wet Ton</b>									
Feedstock Net Expense	US \$ / US Ton		\$ 5.00	\$ -	\$ -	\$ -	\$ (35.00)	\$ -	\$ -
Electric Revenue	US \$ / US Ton	\$ 5.41	\$ 0.73	\$ -	\$ 9.35	\$ 25.50	\$ 42.38	\$ 33.78	\$ 8.61
<small>Electric Revenue is calculated on the PPA Income tab and is allocated to each feedstock by the percentage of methane generated</small>									
RNG Revenue	US \$ / US Ton	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<small>RNG Revenue is calculated on the RNG tab and is allocated to each feedstock by the percentage of methane generated</small>									
Baseline Year 1 CRT Value	US \$ / US Ton	\$ -	\$ -						
<small>Baseline Year 1 CRT Value is calculated on the Carbon Income tab and is only allocated to the livestock manure. Also note that the CRT's are only available for 10 years.</small>									
Baseline Year 1 Green Tag Value	US \$ / US Ton	\$ 0.82	\$ 0.11	\$ -	\$ 1.42	\$ 3.88	\$ 6.45	\$ 5.14	\$ 1.31
<small>Baseline Year 1 Green Tag Value is calculated on the Tag Income tab and is allocated to each feedstock by the percentage of methane generated</small>									

# Anaerobic Digester

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Capital Expenditures		Units	Value	Notes
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**Capital Expenditure Items**

Design		US \$	\$ -	
Construction		US \$	\$ -	
Equipment		US \$	\$ -	
InsZone				
	<b>sub-total</b>	<b>US \$</b>	<b>\$ 2,570,533</b>	per vendor scaled to digester size (75%)

**Capital Expenditure Contingency**

Contingency Factor		Percent	30.0%	
Contingency		US \$	\$ 771,160	
	<b>Anaerobic Digester CapEx</b>	<b>US \$</b>	<b>\$ 3,341,693</b>	Value is used on the Invest Sum and CapEx Sum tabs.

**Depreciation Parameters**

Life Span		Years	7	
Salvage Value		Percent	2.5%	
	<b>Salvage Value</b>	<b>US \$</b>	<b>\$ 83,542</b>	Value is used on the CapEx Sum tab.

**ITC Parameters**

Capital Expenditure ITC Eligible		Percent	98%	
	<b>ITC Eligible Value</b>	<b>US \$</b>	<b>\$ 3,274,859</b>	Value is used on the ITC tab.

**BETC Parameters**

Capital Expenditure BETC Eligible		Percent	100%	
	<b>BETC Eligible Value</b>	<b>US \$</b>	<b>\$ 3,341,693</b>	Value is used on the BETC tab.

Operations & Maintenance		Units	Value	Notes
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**Operation & Maintenance**

Operations & Maintenance		Percent of CapEx	3.00%	
	<b>Anaerobic Digester O&amp;M Expense</b>	<b>US \$ / Year</b>	<b>\$ 77,116</b>	Value is used on the Op Sum tab.

## Anaerobic Digester

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Performance		Units	Value	Notes
<b>Operating</b>				
	Hours / Day		24	
	Days / Year		365	
	<b>Hours / Year</b>		<b>8,760</b>	
<b>Digester Specifications</b>				
	Digester Tank 1 Capacity	m <sup>3</sup>	3,500	
	Digester Tank 2 Capacity	m <sup>3</sup>		
InsZone	<b>Total Digester Capacity</b>	<b>m<sup>3</sup></b>	<b>3,500</b>	
	Organic Loading Rate	kg / m <sup>3</sup> / Day	4.00	
	Capacity of <b>Volatile Solids</b>	Metric Tons / Day	14.00	
	Conversion Factor	US Tons / Metric Ton	1.102	Unit conversion.
	<b>Digester Volatile Solids</b>	<b>US Tons / Day</b>	<b>15.4</b>	Value is used on the <b>Feedstock</b> tab.
	<b>Digester Volatile Solids</b>	<b>US Tons / Year</b>	<b>5,631</b>	
	Digester Operating Capacity on a <b>Volatile Solids</b> Basis	Percent	95.7%	Value is calculated on the <b>Feedstock</b> tab.
<b>Feedstock Utilization Summary</b>				
	Feedstock Utilization	US Tons / Day	135.4	Value is calculated on the <b>Feedstock</b> tab.
	Total Solids in Feedstock	Percent	12.9%	Value is calculated on the <b>Feedstock</b> tab.
	Total Solids in Digestate	Percent	6.3%	Value is calculated on the <b>Feedstock</b> tab.
<b>Methane Yield</b>				
	Methane Yield	MCF / Day	141.5	Value is calculated on the <b>Feedstock</b> tab.
	<b>Methane Yield</b>	<b>MCF / Hour</b>	<b>5.9</b>	Value is calculated on the <b>Feedstock</b> tab.
<b>Digester Methane Parasitic Load (If No CHP is Utilized)</b>				
	Digester Methane Parasitic Load	Percent	0%	Value can be set to represent methane utilized in a boiler when no CHP is available for digester heating.
	Digester Methane Parasitic Load	MCF / Hour	-	
	<b>Net Methane Yield</b>	<b>MCF / Hour</b>	<b>5.9</b>	
<b>Digester Electric Parasitic Load</b>				
	Digester Electric Parasitic Load	kW	5	
	Grid Electric Cost	US \$ / kWh	0.0657	Value is set on the <b>Client</b> tab.
	<b>AD Electric Expense</b>	<b>US \$ / Year</b>	<b>2,878</b>	Value is used on the <b>Op Sum</b> tab.
Client				
<b>Methane Utilization</b>				
	Methane forwarded to CHP	Percent	100%	
	Methane forwarded to RNG	Percent	0%	
InsZone	<b>Total</b>	<b>Percent</b>	<b>100%</b>	
	Methane forwarded to CHP	MCF / Hour	5.9	Value is used on the <b>CHP</b> tab
	Methane forwarded to RNG	MCF / Hour	-	Value is used on the <b>RNG</b> tab
InsZone	<b>Total</b>	<b>MCF / Hour</b>	<b>5.9</b>	

## Combined Heat and Power

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

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May

Capital Expenditures		Units	Value	Notes
Capital Expenditure Items				
CHP Choice:				
Jenbacher - J 312 GS v82 - 633 kW - Container				
Number of CHP Engines		Count	1	
Jenbacher - J 312 GS v82	- 633 kW - Container	US \$	\$ 787,689	Budgetary pricing from Western Energy Systems May, 2009 Values are driven by the CHP selected.
5				
Construction		US \$	\$ 50,000	Container CHP
InsZone		US \$		
sub-total		US \$	\$ 837,689	
Capital Expenditure Contingency				
Contingency Factor		Percent	30.0%	
Contingency		US \$	\$ 251,307	
<b>Combined Heat and Power CapEx</b>		US \$	\$ 1,088,996	Value is zeroed out if methane is not sent to the CHP from the AD tab. Value is used on the CapEx Sum and Invest Sum tabs.
Depreciation Parameters				
Life Span		Years	7	
Salvage Value		Percent	2.5%	
Salvage Value		US \$	\$ 27,225	Value is used on the CapEx Sum tab.
ITC Parameters				
Capital Expenditure ITC Eligible		Percent	100%	
Eligible ITC Value		US \$	\$ 1,088,996	Value is used on the ITC tab.
BETC Parameters				
Capital Expenditure BETC Eligible		Percent	100%	
Eligible BETC Value		US \$	\$ 1,088,996	Value is used on the BETC tab.
Operations & Maintenance		Units	Value	Notes
Operation & Maintenance				
Operations & Maintenance - Low		US \$ / kWh	0.015	Values are driven by the CHP selected.
Operations & Maintenance - High		US \$ / kWh	0.020	Values are driven by the CHP selected.
Operations & Maintenance - Average		US \$ / kWh	0.018	
Operations & Maintenance		US \$ / kWh	\$ 0.015	
Annual Gross Estimated Generation		kWh	5,408,031	
<b>Combined Heat and Power O&amp;M Expense</b>		US \$ / Year	\$ 81,120	Value is zeroed out if methane is not sent to the CHP from the AD tab. Value is used on the Op Sum tab.

Performance		Units	Value	Notes
Operating	Operating	Hours / Day	24	
	Operating	Days / Year	365	As per EC Oregon
	Operating	Hours / Year	8,520	
	CHP Downtime	Days / Year	10	Value is used on the PPA Income tab.
AD Methane Available	AD Methane for CHP Go to Methane Utilization on AD tab	MCF / Hour	5.9	Value is calculated on the AD tab.
CHP Engine Specifications	Consuming	MCF / Hour	5.9793	As per vendor
	Producing	kW	633	As per vendor
	Generating	kWh / MCF / Hour	107.67	Values are driven by the CHP selected.
Electric - Generation	Estimated Generation	kW	635	
	Station Service Requirements as a Percent	Percent	3.0%	
	Station Service Requirements	kW	19	
	- Or -			The Station Service Requirements may be entered as a percent or in kWh. To use the kWh basis be sure to enter the percent basis as 0%.
	Station Service Requirements as kW	kW	-	
	Adjusted Estimated Generation	kW	616	Value is zeroed out if methane is not sent to the CHP from the AD tab. Value is used on the PPA Income tab.
	Estimated Annual Generation	kWh	5,245,790	
CHP Operating Capacity	Percent	100.3%		
<b>Electric - Consumption (Net Metering)</b>				
For modeling a Net Metering scenario be sure to select "None" as the Power Purchase Agreement on the PPA Rates tab.				
Average Annual Electric Consumption	Average Annual Electric Consumption	kWh	-	
	Client's Cost of Electricity	US \$ / kWh	0.0657	Value is set on the Client tab.
	Electric Avoided Expense	US \$ / Year	-	Value is used on the Op Sum tab.
Generation Remaining after Consumption	kWh	616	Value is zeroed out if methane is not sent to the CHP from the AD tab.	
<b>CHP Jacket Heat - Not Dynamic</b>				
Raw Fuel Cost	Raw Fuel Cost	US \$ / Million BTU	22.61	Value is set on the Client tab.
	Operations and Maintenance	Factor	1.3	
	Enthalpy of Hot Water at 230 F	BTU / Lb	196	
	Enthalpy of Feedwater	BTU / Lb	18	
	Overall Boiler Efficiency	Factor	0.825	
	US \$ / 1,000 Lbs		6.34	
	Extracted from Jacket Heat	Million BTU / Hour	1,7207	Based on J316 GS v82 model at partial capacity (Full = 1,716 MMBtu/hour)
	Therms / Hour		17.21	
	Lb / Hour		8,779	
	Available at 230 F	US \$ / Hour	56.67	
<b>CHP Jacket Heat - Revenue</b>				
Amount Utilized	Percent	0.0%		
Utilized Jacket Heat	Therms / Year	-		
Loaded Fuel Cost	US \$ / Therm	3.24	Value is zeroed out if methane is not sent to the CHP from the AD tab.	
CHP Jacket Heat Revenue	US \$ / Year	-	Value is used on the Op Sum tab.	
<b>CHP Jacket Heat - Avoided Expense</b>				
Amount Utilized	Percent	0.0%		
Utilized Jacket Heat	Therms / Year	-		
Loaded Fuel Cost	US \$ / Therm	3.24	Value is zeroed out if methane is not sent to the CHP from the AD tab.	
CHP Jacket Heat Avoided Expense	US \$ / Year	-	Value is used on the Op Sum tab.	
<b>CHP Exhaust Heat - Not Dynamic</b>				
Raw Fuel Cost	Raw Fuel Cost	US \$ / Million BTU	22.61	Value is set on the Client tab.
	Operations and Maintenance	Factor	1.3	
	Enthalpy of Steam	BTU / Lb	1,190	
	Enthalpy of Feedwater	BTU / Lb	18	Value is set above.
	Overall Boiler Efficiency	Factor	0.825	Value is set above.
	US \$ / 1,000 Lbs		41.76	
	Extracted from Jacket Heat	Million BTU / Hour	1,7278	Based on J316 GS v82 model at partial capacity (Full = 1,723 MMBtu/hour)
	Therms / Hour		17.28	
	Lb / Hour		1,452	
	Available at 125 psig using Enthalpy of Steam	US \$ / Hour	60.62	
<b>CHP Exhaust Heat - Revenue</b>				
Amount Utilized	Percent	0%		
Utilized Exhaust Heat	Therms / Year	-		
Loaded Fuel Cost	US \$ / Therm	3.51	Value is zeroed out if methane is not sent to the CHP from the AD tab.	
CHP Exhaust Heat Revenue	US \$ / Year	-	Value is used on the Op Sum tab.	
<b>CHP Exhaust Heat - Avoided Expense</b>				
Amount Utilized	Percent	0.0%		
Utilized Exhaust Heat	Therms / Year	-		
Loaded Fuel Cost	US \$ / Therm	3.51	Value is zeroed out if methane is not sent to the CHP from the AD tab.	
CHP Exhaust Heat Avoided Expense	US \$ / Year	-	Value is used on the Op Sum tab.	

**Power Purchase Agreement Pricing**

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

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NA

**Power Purchase Agreement Selection**

PPA Choice:

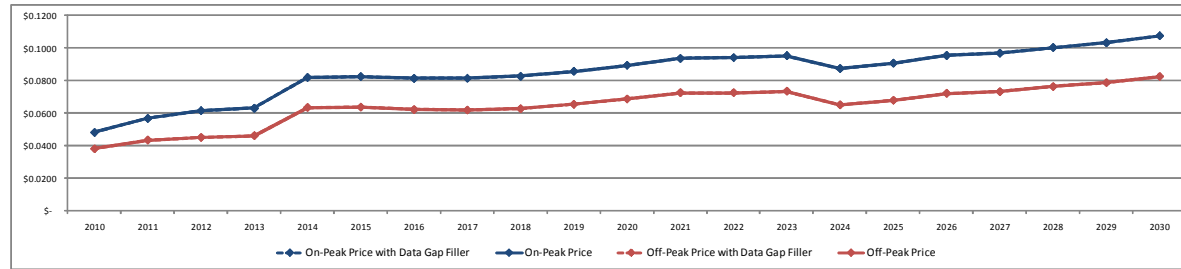
- PacifiCorp - Oregon Schedule 37 (Oct 20, 2008)
- PGE - Schedule 201 (Nov 1, 2007)
- PacifiCorp - Oregon Schedule 37 (September 9, 2009)**
- None

**Power Purchase Agreement Selected** Units

PacifiCorp - Oregon Schedule 37 (September 9, 2009)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
On-Peak Price	US \$ / kWh	\$ 0.0482	\$ 0.0568	\$ 0.0616	\$ 0.0630	\$ 0.0819	\$ 0.0825	\$ 0.0813	\$ 0.0814	\$ 0.0826	\$ 0.0857	\$ 0.0894	\$ 0.0936	\$ 0.0941	\$ 0.0953	\$ 0.0874	\$ 0.0907	\$ 0.0954	\$ 0.0968	\$ 0.1003	\$ 0.1032	\$ 0.1075
Off-Peak Price	US \$ / kWh	\$ 0.0380	\$ 0.0434	\$ 0.0450	\$ 0.0461	\$ 0.0634	\$ 0.0636	\$ 0.0621	\$ 0.0618	\$ 0.0626	\$ 0.0653	\$ 0.0686	\$ 0.0725	\$ 0.0725	\$ 0.0734	\$ 0.0650	\$ 0.0678	\$ 0.0721	\$ 0.0731	\$ 0.0762	\$ 0.0786	\$ 0.0824
On-Peak Price with Data Gap Filler	US \$ / kWh	\$ 0.0482	\$ 0.0568	\$ 0.0616	\$ 0.0630	\$ 0.0819	\$ 0.0825	\$ 0.0813	\$ 0.0814	\$ 0.0826	\$ 0.0857	\$ 0.0894	\$ 0.0936	\$ 0.0941	\$ 0.0953	\$ 0.0874	\$ 0.0907	\$ 0.0954	\$ 0.0968	\$ 0.1003	\$ 0.1032	\$ 0.1075
Off-Peak Price with Data Gap Filler	US \$ / kWh	\$ 0.0380	\$ 0.0434	\$ 0.0450	\$ 0.0461	\$ 0.0634	\$ 0.0636	\$ 0.0621	\$ 0.0618	\$ 0.0626	\$ 0.0653	\$ 0.0686	\$ 0.0725	\$ 0.0725	\$ 0.0734	\$ 0.0650	\$ 0.0678	\$ 0.0721	\$ 0.0731	\$ 0.0762	\$ 0.0786	\$ 0.0824

Note: Years with no PPA rate available, indicated by "N/A", above are forecasted by calculating the average price increase for the prior three years.



**Power Purchase Agreement Income**  
**EC Oregon - AD Financial Feasibility Model v2.3**  
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	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
<b>Available On-Peak and Off-Peak Hours</b> <small>Units</small>																						
Available On-Peak and Off-Peak Days	Available	Days / Year	365	366	365	365	365	365	365	365	365	365	365	365	365	366	365	365	365	366	365	365
Number of Sundays	Sundays / Year	52	53	52	52	52	52	53	52	52	52	52	52	52	53	52	52	52	52	53	52	52
Number of NERC Holidays	Holidays / Year	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
<b>CHP Downtime = 10</b> <small>Days / Year</small>																						
<i>Value is calculated on the CHP tab</i>																						
CHP Downtime On-Peak	Days / Year	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
CHP Downtime Off-Peak	Days / Year	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
On-Peak	Days / Year	299	299	299	299	299	300	298	299	299	300	299	299	299	300	299	299	299	299	299	299	299
Off-Peak	Days / Year	56	57	56	56	56	56	57	56	56	56	56	56	56	57	56	56	56	56	57	56	56
On-Peak and Off-Peak	Days / Year	355	356	355	355	355	356	355	355	355	356	355	355	355	356	355	355	355	355	356	355	355
<b>Available On-Peak and Off-Peak Hours</b> <small>Units</small>																						
On-Peak Hours = 16	Hours / Day																					
Off-Peak Hours = 8	Hours / Day																					
<i>Values are set on Parameters tab</i>																						
On-Peak	Hours / Year	4,784	4,784	4,784	4,784	4,784	4,800	4,768	4,784	4,784	4,800	4,784	4,784	4,768	4,800	4,784	4,784	4,784	4,784	4,784	4,784	4,784
Off-Peak	Hours / Year	3,736	3,760	3,736	3,736	3,736	3,744	3,752	3,736	3,736	3,744	3,736	3,736	3,752	3,744	3,736	3,736	3,736	3,736	3,760	3,736	3,736
<b>Estimated kWh Generation</b> <small>Units</small>																						
<i>Value is calculated on the CHP tab</i>																						
CHP Adjusted Estimated kWh = 616	kWh																					
On-Peak	kWh / Year	2,945,523	2,945,523	2,945,523	2,945,523	2,945,523	2,955,375	2,935,672	2,945,523	2,945,523	2,955,375	2,945,523	2,945,523	2,935,672	2,955,375	2,945,523	2,945,523	2,945,523	2,945,523	2,945,523	2,945,523	2,945,523
Off-Peak	kWh / Year	2,300,266	2,315,043	2,300,266	2,300,266	2,300,266	2,305,192	2,310,118	2,300,266	2,300,266	2,305,192	2,300,266	2,300,266	2,310,118	2,305,192	2,300,266	2,300,266	2,300,266	2,315,043	2,300,266	2,300,266	2,300,266
Total	kWh / Year	5,245,790	5,260,567	5,245,790	5,245,790	5,245,790	5,260,567	5,245,790	5,245,790	5,245,790	5,260,567	5,245,790	5,245,790	5,245,790	5,260,567	5,245,790	5,245,790	5,245,790	5,260,567	5,245,790	5,245,790	5,245,790
<b>Power Purchase Agreement Selected</b> <small>Units</small>																						
<b>PacifiCorp - Oregon Schedule 37 (September 9, 2009)</b>																						
<i>PPA Rate Schedule is selected on the PPA Rates tab</i>																						
On-Peak Price	US \$ / kWh	\$ 0.0568	\$ 0.0616	\$ 0.0630	\$ 0.0619	\$ 0.0625	\$ 0.0613	\$ 0.0614	\$ 0.0626	\$ 0.0657	\$ 0.0694	\$ 0.0636	\$ 0.0941	\$ 0.0953	\$ 0.0874	\$ 0.0907	\$ 0.0954	\$ 0.0968	\$ 0.1003	\$ 0.1032	\$ 0.1075	\$ 0.1075
Off-Peak Price	US \$ / kWh	\$ 0.0434	\$ 0.0450	\$ 0.0461	\$ 0.0634	\$ 0.0636	\$ 0.0621	\$ 0.0618	\$ 0.0626	\$ 0.0653	\$ 0.0686	\$ 0.0725	\$ 0.0725	\$ 0.0734	\$ 0.0650	\$ 0.0678	\$ 0.0721	\$ 0.0731	\$ 0.0762	\$ 0.0786	\$ 0.0824	\$ 0.0824
<b>Power Purchase Agreement Income</b> <small>Units</small>																						
On-Peak Income	US \$ / Year	\$ 167,306	\$ 181,444	\$ 185,568	\$ 241,238	\$ 243,006	\$ 240,272	\$ 238,964	\$ 243,300	\$ 252,431	\$ 264,210	\$ 275,701	\$ 277,174	\$ 279,770	\$ 258,300	\$ 267,159	\$ 281,003	\$ 285,127	\$ 295,436	\$ 303,978	\$ 316,644	\$ 316,644
Off-Peak Income	US \$ / Year	\$ 99,832	\$ 104,177	\$ 106,042	\$ 145,837	\$ 146,297	\$ 143,152	\$ 142,765	\$ 143,997	\$ 150,207	\$ 158,136	\$ 166,769	\$ 166,769	\$ 169,593	\$ 149,837	\$ 155,958	\$ 165,849	\$ 168,149	\$ 176,406	\$ 180,801	\$ 189,542	\$ 189,542
Electric Revenue	US \$ / Year	\$ 267,137	\$ 285,621	\$ 291,610	\$ 387,075	\$ 389,303	\$ 383,424	\$ 381,729	\$ 387,297	\$ 402,639	\$ 422,347	\$ 442,470	\$ 443,943	\$ 449,363	\$ 408,137	\$ 423,117	\$ 446,852	\$ 453,276	\$ 471,842	\$ 484,779	\$ 506,186	\$ 506,186
<i>Value for Year 1 is used on the Op Sum tab</i>																						
<i>All yearly values are used on the Income Statement</i>																						

## Digestate Handling and Nutrient Recovery

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

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### Digestate Dewatering

Capital Expenditures		Units	Value	Notes
<b>Capital Expenditure Items</b>				
Construction		US \$	\$ 30,000	in AD cost estimate
Equipment		US \$	\$ 51,779	
InsZone		US \$		
	<b>sub-total</b>	<b>US \$</b>	<b>\$ 81,779</b>	
<b>Capital Expenditure Contingency</b>				
	Contingency Factor	Percent	30.0%	
	Contingency	US \$	\$ 24,534	
	<b>Digestate Dewatering CapEx</b>	<b>US \$</b>	<b>\$ 106,313</b>	Value is used on the <b>CapEx Sum</b> and <b>Invest Sum</b> tabs
<b>Depreciation Parameters</b>				
	Life Span	Years	7	
	Salvage Value	Percent	2.5%	
	<b>Salvage Value</b>	<b>US \$</b>	<b>\$ 2,658</b>	Value is used on the <b>CapEx Sum</b> tab
<b>ITC Parameters</b>				
	Capital Expenditure ITC Eligible	Percent	100%	
	<b>Eligible ITC Value</b>	<b>US \$</b>	<b>\$ 106,313</b>	Value is used on the <b>ITC</b> tab
<b>BETC Parameters</b>				
	Capital Expenditure BETC Eligible	Percent	100%	
	<b>Eligible BETC Value</b>	<b>US \$</b>	<b>\$ 106,313</b>	Value is used on the <b>BETC</b> tab
<b>Operations &amp; Maintenance</b>		<b>Units</b>	<b>Value</b>	<b>Notes</b>
<b>Operation &amp; Maintenance</b>				
	Operations & Maintenance	Percent of CapEx	3.00%	
	<b>Digestate Dewatering O&amp;M Expense</b>	<b>US \$ / Year</b>	<b>\$ 2,453</b>	Value is used on the <b>Op Sum</b> tab

Digestate Handling and Nutrient Recovery

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Performance		Units	Value	Notes
Operating		Days / Year	365	
Digestate Available				
	Dry Solids in Digestate	US Tons / Day	7.9	Value is calculated on the Feedstock tab
	Liquid in Digestate	US Tons / Day	117.9	Value is calculated on the Feedstock tab
	Digestate	US Tons / Day	125.8	Value is calculated on the Feedstock tab
Nutrient Values				
	N in Digestate	US Tons / Day	0.28	Value is calculated on the Feedstock tab
	N in Digestate	US Tons / Year	103.4	Value is calculated on the Feedstock tab
	P in Digestate	US Tons / Day	-	Value is calculated on the Feedstock tab
	P in Digestate	US Tons / Year	-	Value is calculated on the Feedstock tab
	N Soluble (NH <sub>4</sub> )	Percent	75.0%	
	N Insoluble (Organic)	Percent	25.0%	
	N Value	US \$ / Pound	\$ 1.10	Based on Organic N
	P Value	US \$ / Pound	\$ 1.25	Based on \$1.050 / Ton P205
Digestate Fiber Fraction Available				
	Solids Capture Rate	Percent	70%	Variable based on equipment
	Total Solids in Fiber	Percent	37%	Estimate post dewatering
	Fiber	US Tons / Day	18.4	
	Fiber	US Tons / Year	6,715	
NH <sub>4</sub> Available in Fiber				
	Water in Fiber	US Tons / Day	12.88	
	Liquid in Digestate	US Tons / Day	117.93	Value is calculated on the Feedstock tab
	N in Digestate	US Tons / Day	0.28	Value is calculated on the Feedstock tab
	N Soluble (NH <sub>4</sub> )	Percent	75.0%	
	N Fiber Nutrients - NH <sub>4</sub>	US Tons / Day	0.02	
Organic N Available in Fiber				
	Solids Capture Rate	Percent	70%	Value is calculated on the Feedstock tab
	N in Digestate	US Tons / Day	0.28	
	N Insoluble (Organic)	Percent	25.0%	
	N Fiber Nutrients - Organic N	US Tons / Day	0.05	
Total N Available in Fiber				
	N in Fiber	US Tons / Day	0.07	
	N in Fiber	US Tons / Year	26.6	
Total P Available in Fiber				
	P in Digestate	US Tons / Day	-	
	Solids Capture Rate	Percent	70%	
	P in Fiber	US Tons / Day	-	
	P in Fiber	US Tons / Year	-	
Calculated Fiber Nutrient Value				
	Calculated Fiber Nutrient Value from N	US \$ / Year	\$ 58,486	
	Calculated Fiber Nutrient Value from P	US \$ / Year	\$ -	
	Calculated Fiber Nutrient Value	US \$ / US Ton	\$ 8.71	N=0.4% and P as P205=0%
US Tons to Yards Conversion				
	Fiber Conversion Factor	US Tons / Yards <sup>3</sup>	0.45	From lab results in Terra Source Report
Fiber Revenue				
	Fiber to Sell	Percent	70%	
	Fiber to Sell	US Tons / Year	4,701	
	Fiber to Keep	US Tons / Year	2,015	
	Fiber to Sell	Yards <sup>3</sup> / Year	10,446	
	Use Calculated Fiber Value Price?	Yes / No	No	Enter "Yes" to use calculated value, enter "No" to use override value per Jerry Noble
	Override Fiber Value	US \$ / US Ton	\$ 10.00	
	Fiber Nutrient Revenue	US \$ / Year	\$ 47,008	Value is used on the Op Sum tab
	Value in Yards	US \$ / Yards <sup>3</sup>	\$ 4.50	
Fiber Avoided Expense				
	Fiber to Retain	Percent	30%	
	Fiber to Retain	US Tons / Year	2,015	
	Fiber to Retain	Yards <sup>3</sup> / Year	4,477	
	Use Calculated Fiber Value Price?	Yes / No	No	Enter "Yes" to use calculated value, enter "No" to use override value
	Override Fiber Value	US \$ / US Ton	\$ 4.76	paye \$0.01 a month for 30% of bawdwing, 70% is free air saw dust. Therefore the avoided cost may instead only be \$0.0005.
	Fiber Nutrient Avoided Expense	US \$ / Year	\$ 9,590	Value is used on the Op Sum tab
	Value in Yards	US \$ / Yards <sup>3</sup>	\$ 2.14	
Digestate Liquid Fraction Remaining				
	Digestate	US Tons / Day	125.8	Value is calculated on the Feedstock tab
	Fiber	US Tons / Day	18.4	
	Digestate Liquid Fraction Remaining	US Tons / Day	107.4	

## Feedstock Handling and Storage

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### Feed Handling Equipment

Capital Expenditures		Units	Value	Notes
<b>Capital Expenditure Items</b>				
<b>Reception and feeding equipment</b>				
	Dry solid feeder	US \$		
	Extruder for cell disruption	US \$	\$ 176,777	per vendor
	Dry material pump	US \$	\$ 205,787	per vendor
		US \$	\$ 33,996	per vendor
		US \$		
		US \$		
	<b>sub-total</b>	<b>US \$</b>	<b>\$ 416,559</b>	
<b>Capital Expenditure Contingency</b>				
	Contingency Factor	Percent	30.0%	
	Contingency	US \$	\$ 124,968	
	<b>Feed Handling Equipment CapEx</b>	<b>US \$</b>	<b>\$ 541,527</b>	Value is used on the CapEx Sum and Invest Sum tabs
<b>Depreciation Parameters</b>				
	Life Span	Years	7	
	Salvage Value	Percent	2.5%	
	<b>Salvage Value</b>	<b>US \$</b>	<b>\$ 13,538</b>	Value is used on the CapEx Sum tab
<b>ITC Parameters</b>				
	Percent of Capital Expenditure ITC Eligible	Percent	100%	
	<b>Eligible ITC Value</b>	<b>US \$</b>	<b>\$ 541,527</b>	Value is used on the ITC tab
<b>BETC Parameters</b>				
	Percent of Capital Expenditure BETC Eligible	Percent	100%	
	<b>Eligible BETC Value</b>	<b>US \$</b>	<b>\$ 541,527</b>	Value is used on the BETC tab
<b>Operations &amp; Maintenance</b>				
<b>Operation &amp; Maintenance</b>				
	Operations & Maintenance Percent of Capital Expenditure	Percent of CapEx	3.00%	
	<b>Feed Handling Equipment O&amp;M Expense</b>	<b>US \$ / Year</b>	<b>\$ 12,497</b>	Value is used on the Op Sum tab

## Feedstock Handling and Storage

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### Feedstock & Fiber Storage

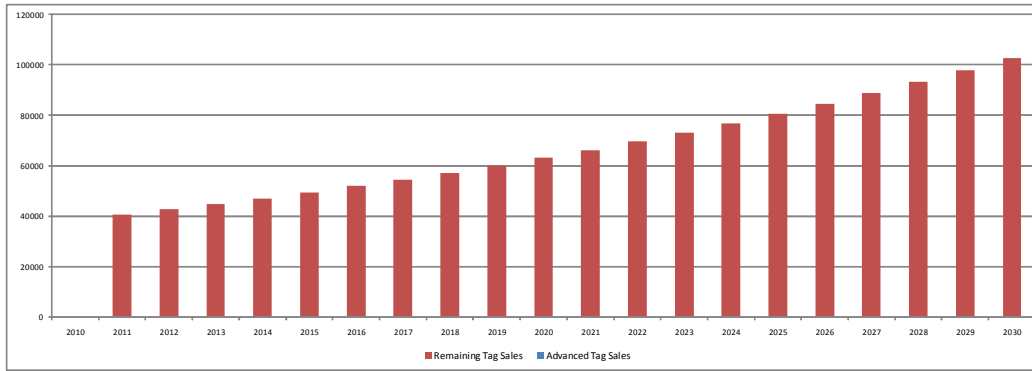
Capital Expenditures		Units	Value	Notes
<b>Capital Expenditure Items</b>				
	Design	US \$	\$ 15,000	
	Equipment	US \$	\$ 30,000	
	Construction	US \$	\$ 70,000	
InsZone				
	<b>sub-total</b>	<b>US \$</b>	<b>\$ 115,000</b>	
<b>Capital Expenditure Contingency</b>				
	Contingency Factor	Percent	30.0%	
	Contingency	US \$	\$ 34,500	
	<b>Feedstock &amp; Fiber Storage CapEx</b>	<b>US \$</b>	<b>\$ 149,500</b>	Value is used on the <b>CapEx Sum</b> and <b>Invest Sum</b> tabs
<b>Depreciation Parameters</b>				
	Life Span	Years	7	
	Salvage Value	Percent	2.5%	
	<b>Salvage Value</b>	<b>US \$</b>	<b>\$ 3,738</b>	Value is used on the <b>CapEx Sum</b> tab
<b>ITC Parameters</b>				
	Capital Expenditure ITC Eligible	Percent	0%	
	<b>Eligible ITC Value</b>	<b>US \$</b>	<b>\$ -</b>	Value is used on the <b>ITC</b> tab
<b>BETC Parameters</b>				
	Capital Expenditure BETC Eligible	Percent	100%	
	<b>Eligible BETC Value</b>	<b>US \$</b>	<b>\$ 149,500</b>	Value is used on the <b>BETC</b> tab
<b>Operations &amp; Maintenance</b>		<b>Units</b>	<b>Value</b>	<b>Notes</b>
<b>Operation &amp; Maintenance</b>				
	Operations & Maintenance Percent of Capital Expenditure	Percent of CapEx	2.00%	
	<b>Feedstock &amp; Fiber Storage O&amp;M Expense</b>	<b>US \$ / Year</b>	<b>\$ 2,300</b>	Value is used on the <b>Op Sum</b> tab

Green Tag Income (REC's)

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7/26/09

Green Tag Income			Units	Value	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tags Available	Total kWh per Year Available	kWh / Year Tags / Year			5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790	5,245,790
					5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246	5,246
Advanced Tag Sales	Sold in Advance	Years Tags / Year	10		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Sold in Advance	US \$ / Tag Percent			\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Annual Increase	US \$ / Year			\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
	Discount Rate	Percent	0.00%																						
	Advanced Tag Sales	US \$			\$ -																				
	Simple Tag Value	US \$																							
Remaining Tag Sales	Tags Remaining	Tags / Year			5,246	5,261	5,246	5,246	5,246	5,246	5,261	5,246	5,246	5,246	5,261	5,246	5,246	5,246	5,261	5,246	5,246	5,246	5,261	5,246	5,246
	Starting Selling Price	US \$ / Tag	per BEF June 2, 2009 \$ 7.75		\$ 7.75	\$ 8.14	\$ 8.54	\$ 8.97	\$ 9.42	\$ 9.89	\$ 10.39	\$ 10.91	\$ 11.45	\$ 12.02	\$ 12.62	\$ 13.26	\$ 13.92	\$ 14.61	\$ 15.34	\$ 16.11	\$ 16.92	\$ 17.76	\$ 18.65	\$ 19.58	
	Annual Increase	Percent	5.00%																						
	Remaining Tag Sales	US \$ / Year			\$ 40,655	\$ 42,808	\$ 44,822	\$ 47,063	\$ 49,416	\$ 52,033	\$ 54,881	\$ 57,205	\$ 60,046	\$ 63,247	\$ 66,223	\$ 69,534	\$ 73,010	\$ 76,877	\$ 80,494	\$ 84,519	\$ 88,744	\$ 93,444	\$ 97,841	\$ 102,733	



## Other Project Costs

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Capital Expenditures		Units	Value	Notes
<b>Capital Expenditure Items</b>				
	Permits	US \$	\$ 5,000	Paid for by BEF and ETO
	Electric Interconnection	US \$	\$ 125,000	
	Feasibility Study	US \$	\$ -	
	Project Management	US \$	\$ 210,000	
InsZone	<b>sub-total</b>	<b>US \$</b>	<b>\$ 340,000</b>	
<b>Capital Expenditure Contingency</b>				
	Contingency Factor	Percent	30.0%	
	Contingency	US \$	\$ 102,000	
	<b>Other Project Costs CapEx</b>	<b>US \$</b>	<b>\$ 442,000</b>	Value is used on the <b>CapEx Sum</b> and <b>Invest Sum</b> tabs
<b>Depreciation Parameters</b>				
	Life Span	Years	7	
	Salvage Value	Percent	2.5%	
	<b>Salvage Value</b>	<b>US \$</b>	<b>\$ 11,050</b>	Value is used on the <b>CapEx Sum</b> tab
<b>ITC Parameters</b>				
	Capital Expenditure ITC Eligible	Percent	0%	
	<b>Eligible ITC Value</b>	<b>US \$</b>	<b>\$ -</b>	Value is used on the <b>ITC</b> tab
<b>BETC Parameters</b>				
	Capital Expenditure BETC Eligible	Percent	100%	
	<b>Eligible BETC Value</b>	<b>US \$</b>	<b>\$ 442,000</b>	Value is used on the <b>BETC</b> tab

## Investment Summary

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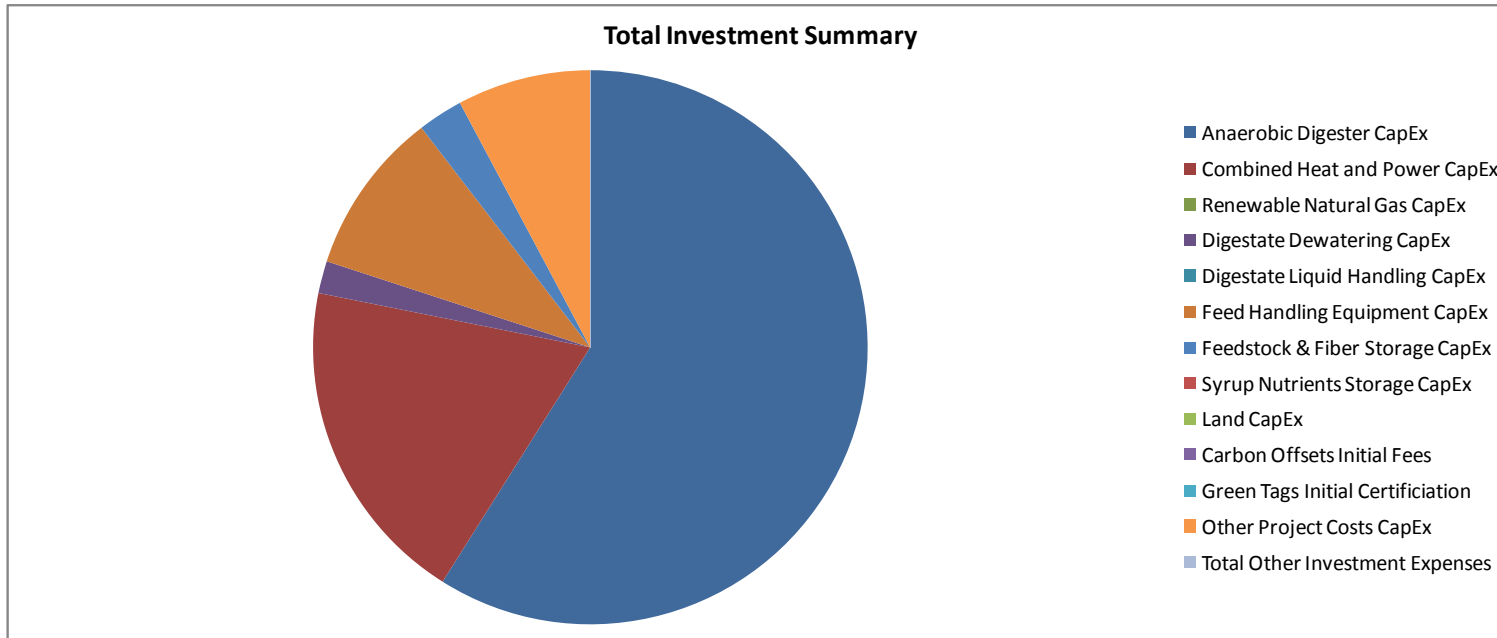
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### Total Investment Summary Notes

Investment Item	Cost	Percent of Total	Percent ITC Eligible	ITC Eligible Value	Percent BETC Eligible	BETC Eligible Value
<a href="#">GoTo</a> Anaerobic Digester CapEx	\$ 3,341,693	58.9%	98%	\$ 3,274,859	100%	\$ 3,341,693
<a href="#">GoTo</a> Combined Heat and Power CapEx	\$ 1,088,996	19.2%	100%	\$ 1,088,996	100%	\$ 1,088,996
<a href="#">GoTo</a> Renewable Natural Gas CapEx	\$ -	0.0%	0%	\$ -	0%	\$ -
<a href="#">GoTo</a> Digestate Dewatering CapEx	\$ 106,313	1.9%	100%	\$ 106,313	100%	\$ 106,313
<a href="#">GoTo</a> Digestate Liquid Handling CapEx	\$ -	0.0%	0%	\$ -	0%	\$ -
<a href="#">GoTo</a> Feed Handling Equipment CapEx	\$ 541,527	9.6%	100%	\$ 541,527	100%	\$ 541,527
<a href="#">GoTo</a> Feedstock & Fiber Storage CapEx	\$ 149,500	2.6%	0%	\$ -	100%	\$ 149,500
<a href="#">GoTo</a> Syrup Nutrients Storage CapEx	\$ -	0.0%	100%	\$ -	0%	\$ -
<a href="#">GoTo</a> Land CapEx	\$ -	0.0%	N/A	N/A	N/A	N/A
<a href="#">GoTo</a> Carbon Offsets Initial Fees	\$ -	0.0%	0%	\$ -	0%	\$ -
<a href="#">GoTo</a> Green Tags Initial Certification	\$ -	0.0%	0%	\$ -	0%	\$ -
<a href="#">GoTo</a> Other Project Costs CapEx	\$ 442,000	7.8%	0%	\$ -	100%	\$ 442,000
<a href="#">GoTo</a> Total Other Investment Expenses	\$ -	0.0%	0%	\$ -	0%	\$ -
<b>Total Investment</b>	<b>\$ 5,670,029</b>	<b>100.0%</b>		<b>\$ 5,011,695</b>		<b>\$ 5,670,029</b>

These values are used on the Funding tab



## Capital Expenditure Summary

EC Oregon - AD Financial Feasibility Model v2.3

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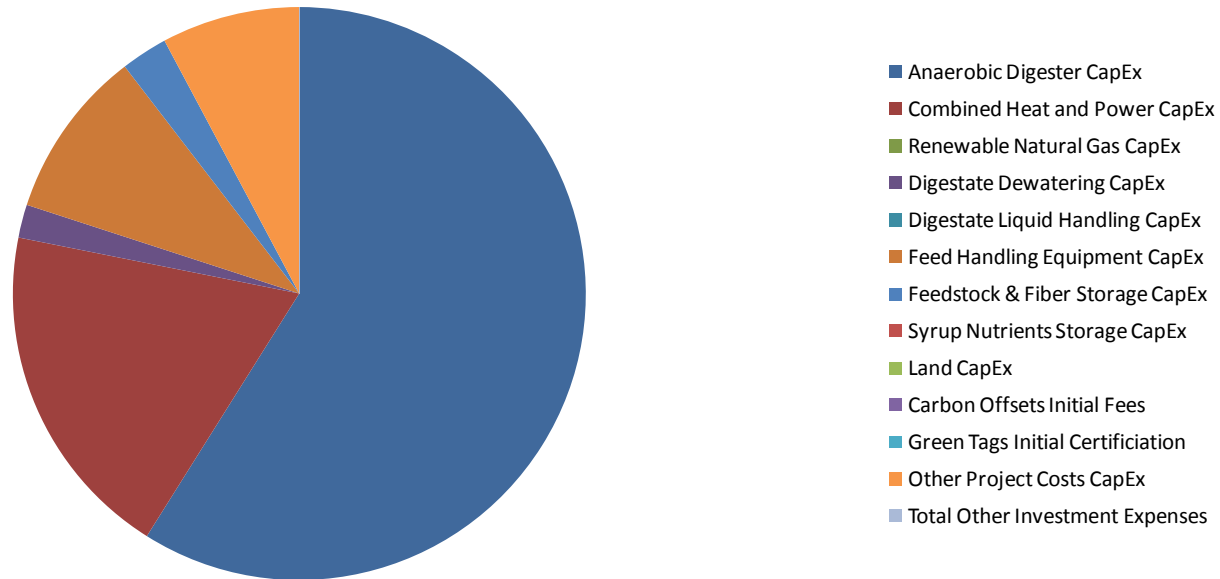
[New](#)

### Capital Expenditures Summary Notes

Capital Expenditure Item	Capital Expenditure	Percent of Total	Life Span in Years	Salvage Value Percent	Salvage Value
<a href="#">GoTo</a> Anaerobic Digester CapEx	\$ 3,341,693	58.9%	7	2.5%	\$ 83,542
<a href="#">GoTo</a> Combined Heat and Power CapEx	\$ 1,088,996	19.2%	7	2.5%	\$ 27,225
<a href="#">GoTo</a> Renewable Natural Gas CapEx	\$ -	0.0%	-	0.0%	\$ -
<a href="#">GoTo</a> Digestate Dewatering CapEx	\$ 106,313	1.9%	7	2.5%	\$ 2,658
<a href="#">GoTo</a> Digestate Liquid Handling CapEx	\$ -	0.0%	7	2.5%	\$ -
<a href="#">GoTo</a> Feed Handling Equipment CapEx	\$ 541,527	9.6%	7	2.5%	\$ 13,538
<a href="#">GoTo</a> Feedstock & Fiber Storage CapEx	\$ 149,500	2.6%	7	2.5%	\$ 3,738
<a href="#">GoTo</a> Syrup Nutrients Storage CapEx	\$ -	0.0%	-	0.0%	\$ -
<a href="#">GoTo</a> Carbon Offsets Initial Fees	\$ -	0.0%	-	0.0%	\$ -
<a href="#">GoTo</a> Green Tags Initial Certification	\$ -	0.0%	-	0.0%	\$ -
<a href="#">GoTo</a> Other Project Costs CapEx	\$ 442,000	7.8%	7	2.5%	\$ 11,050
<small>InsZone</small>					
<b>Total Capital Expenditures</b>	<b>\$ 5,670,029</b>	<b>100.0%</b>			<b>\$ 141,751</b>

These values are used on the Depreciation tab

### Total Investment Summary



## Year 1 Baseline Operations Summary

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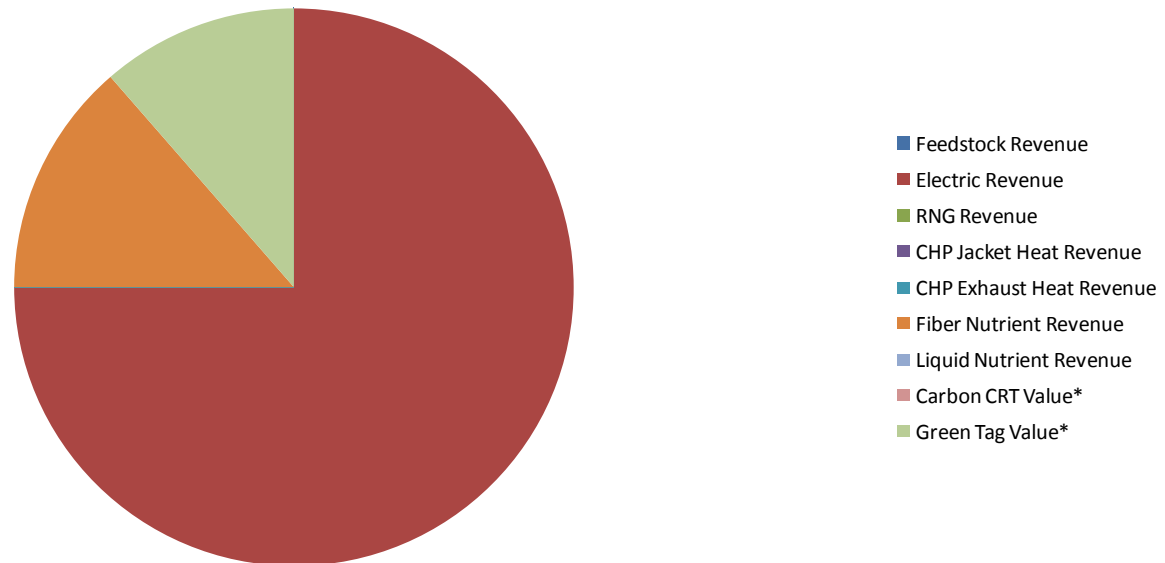
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### Year 1 Baseline Revenue Summary Notes

Revenue Item	Revenue	Percent of Total	Inflation Rate	
<a href="#">GoTo</a> Feedstock Revenue	\$ -	0.0%	3.0%	These values are used on the <b>Income Statement</b>
<a href="#">GoTo</a> Electric Revenue	\$ 267,137	75.0%	Projected	
<a href="#">GoTo</a> RNG Revenue	\$ -	0.0%	3.0%	
<a href="#">GoTo</a> CHP Jacket Heat Revenue	\$ -	0.0%	3.0%	
<a href="#">GoTo</a> CHP Exhaust Heat Revenue	\$ -	0.0%	3.0%	
<a href="#">GoTo</a> Fiber Nutrient Revenue	\$ 48,419	13.6%	3.0%	
<a href="#">GoTo</a> Liquid Nutrient Revenue	\$ -	0.0%	3.0%	
<a href="#">GoTo</a> Carbon CRT Value*	\$ -	0.0%	Projected	*Does not reflect advanced sales. Fewer CRT's are available in year 1. CRT's are only credited for 10 years.
<a href="#">GoTo</a> Green Tag Value* InsZone	\$ 40,655	11.4%	Projected	*Does not reflect advanced sales
<b>Total Revenue Summary</b>	<b>\$ 356,211</b>	<b>100.0%</b>		

Year 1 Baseline Revenue Summary

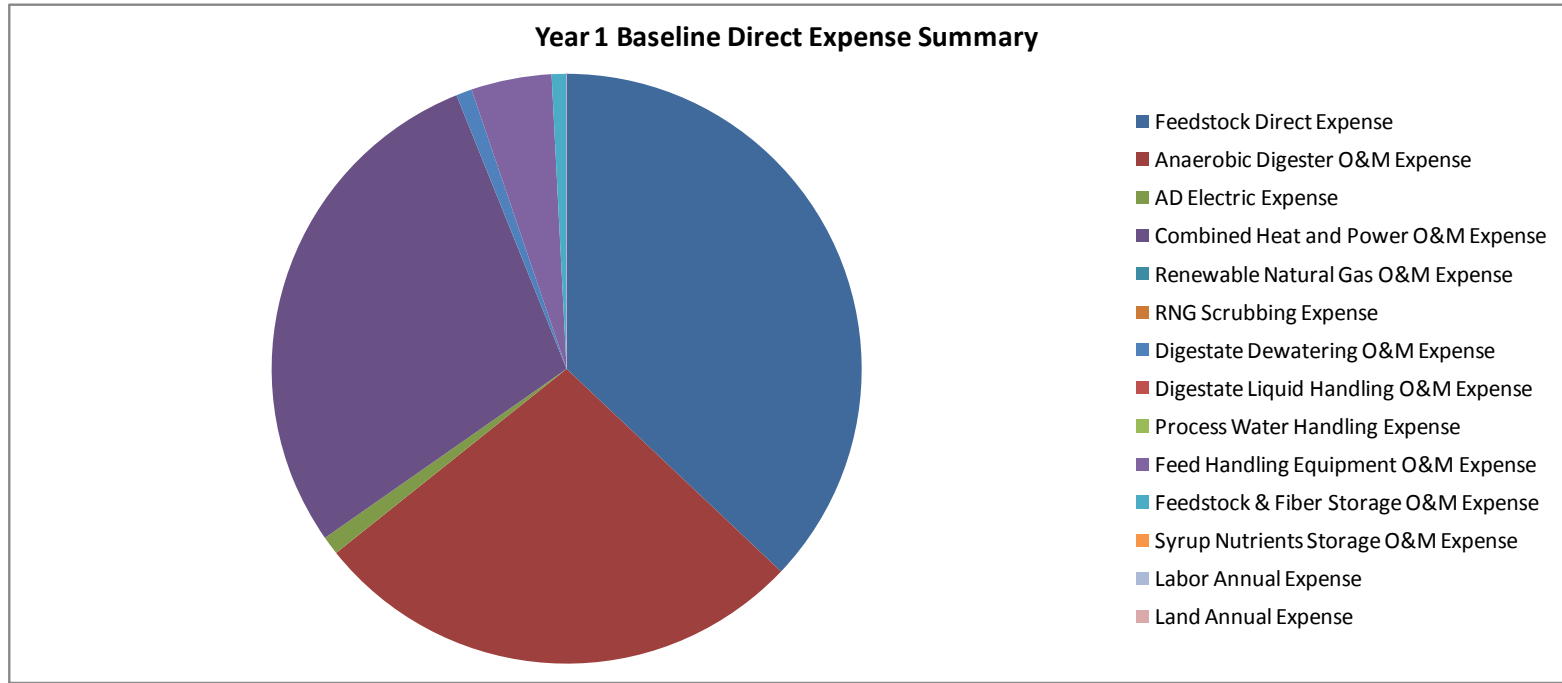


**Year 1 Baseline Direct Expense Summary** Notes

Direct Expense Item	Direct Expense	Percent of Total	Inflation Rate
Feedstock Direct Expense	\$ (108,150)	37.1%	3.0%
Anaerobic Digester O&M Expense	\$ (79,429)	27.2%	3.0%
AD Electric Expense	\$ (2,964)	1.0%	3.0%
Combined Heat and Power O&M Expense	\$ (83,554)	28.6%	3.0%
Renewable Natural Gas O&M Expense	\$ -	0.0%	3.0%
RNG Scrubbing Expense	\$ -	0.0%	3.0%
Digestate Dewatering O&M Expense	\$ (2,527)	0.9%	3.0%
Digestate Liquid Handling O&M Expense	\$ -	0.0%	3.0%
Process Water Handling Expense	\$ -	0.0%	3.0%
Feed Handling Equipment O&M Expense	\$ (12,872)	4.4%	3.0%
Feedstock & Fiber Storage O&M Expense	\$ (2,369)	0.8%	3.0%
Syrup Nutrients Storage O&M Expense	\$ -	0.0%	3.0%
Labor Annual Expense	\$ -	0.0%	3.0%
Land Annual Expense	\$ -	0.0%	3.0%
Carbon Offsets Annual Fees	\$ -	0.0%	3.0%
Green Tags Annual Fees	\$ -	0.0%	3.0%
<b>Total Direct Expense Summary</b>	<b>\$ (291,865)</b>	<b>100.0%</b>	

These values are used on the Income Statement

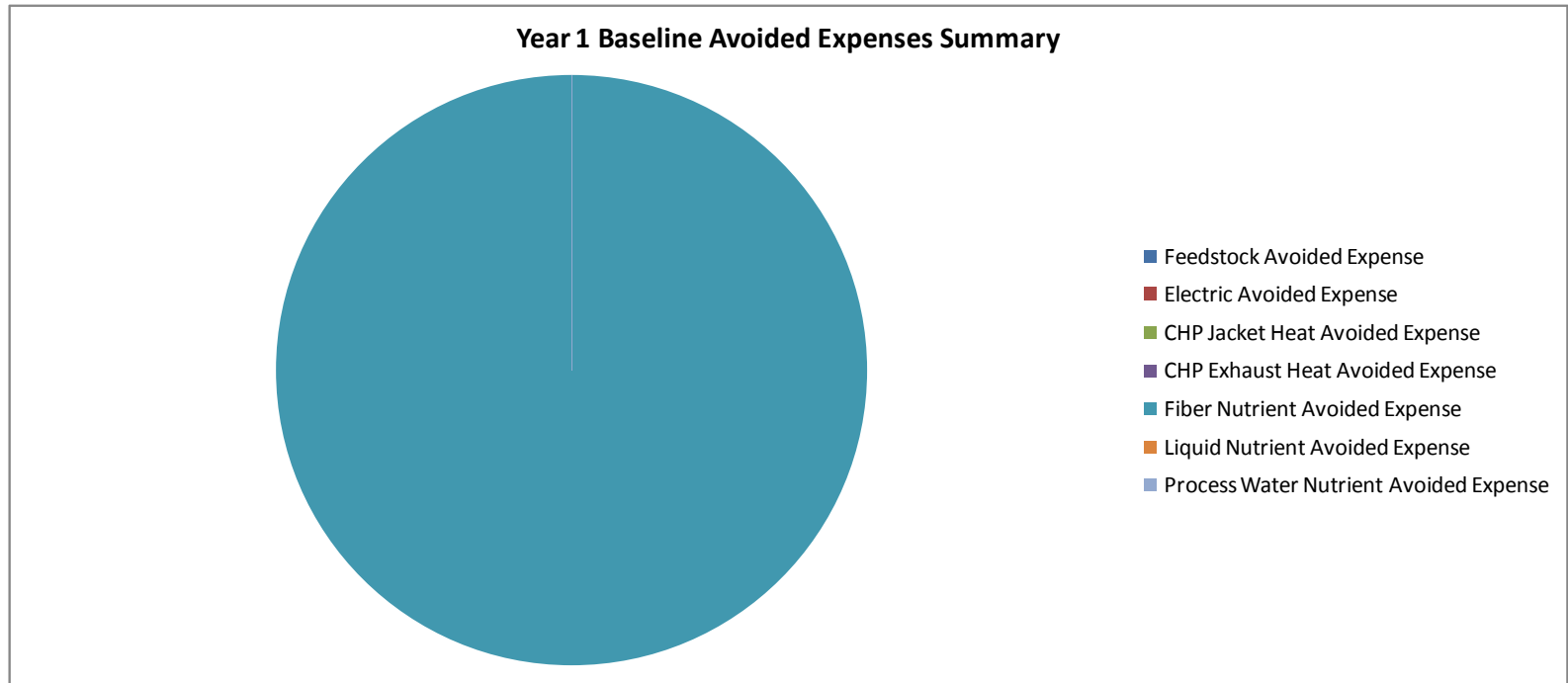
CRT's are only available for 10 years



**Year 1 Baseline Avoided Expenses Summary** Notes

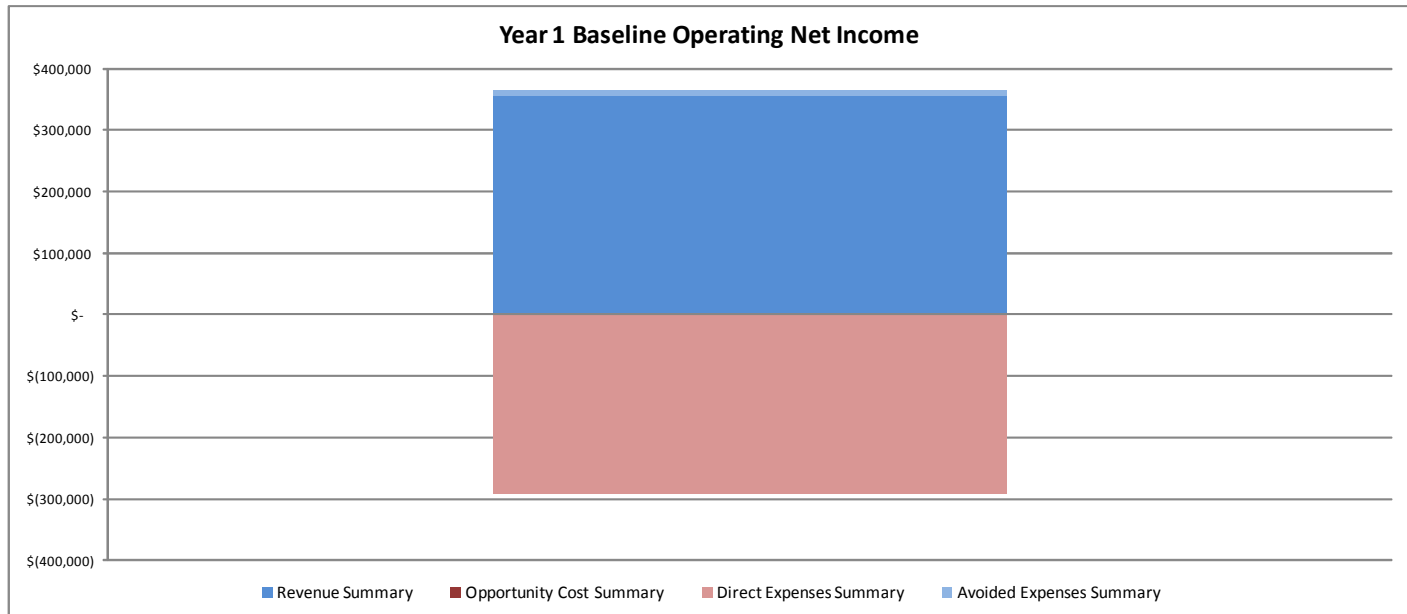
Avoided Expense Item	Avoided Expense	Percent of Total	Inflation Rate
Feedstock Avoided Expense	\$ -	0.0%	3.0%
Electric Avoided Expense	\$ -	0.0%	3.0%
CHP Jacket Heat Avoided Expense	\$ -	0.0%	3.0%
CHP Exhaust Heat Avoided Expense	\$ -	0.0%	3.0%
Fiber Nutrient Avoided Expense	\$ 9,877	100.0%	3.0%
Liquid Nutrient Avoided Expense	\$ -	0.0%	3.0%
Process Water Nutrient Avoided Expense	\$ -	0.0%	3.0%
<b>Total Avoided Expense Summary</b>	<b>\$ 9,877</b>	<b>100.0%</b>	

These values are used on the Income Statement



<b>Year 1 Baseline Net Income Summary</b>	Notes
---	-------

<b>Revenue</b>			
	Revenue Summary	\$	356,211
	Opportunity Cost Summary	\$	-
InsZone			
	<b>Total Revenue</b>	<b>\$</b>	<b>356,211</b>
<b>Expenses</b>			
	Direct Expenses Summary	\$	(291,865)
	Avoided Expenses Summary	\$	9,877
InsZone			
	<b>Total Expenses</b>	<b>\$</b>	<b>(281,988)</b>
	<b>Baseline Operating Net Income (EBITDA)</b>	<b>\$</b>	<b>74,223</b>



<b>Baseline Simple Payback</b>	
--------------------------------	--

Total Investment	\$	5,670,029
Revenue Summary	\$	356,211
Avoided Expenses Summary	\$	9,877
	<b>\$</b>	<b>366,088</b>
<b>Simple Payback Period</b>		<b>15.5</b>

## Operations and Maintenance Summary

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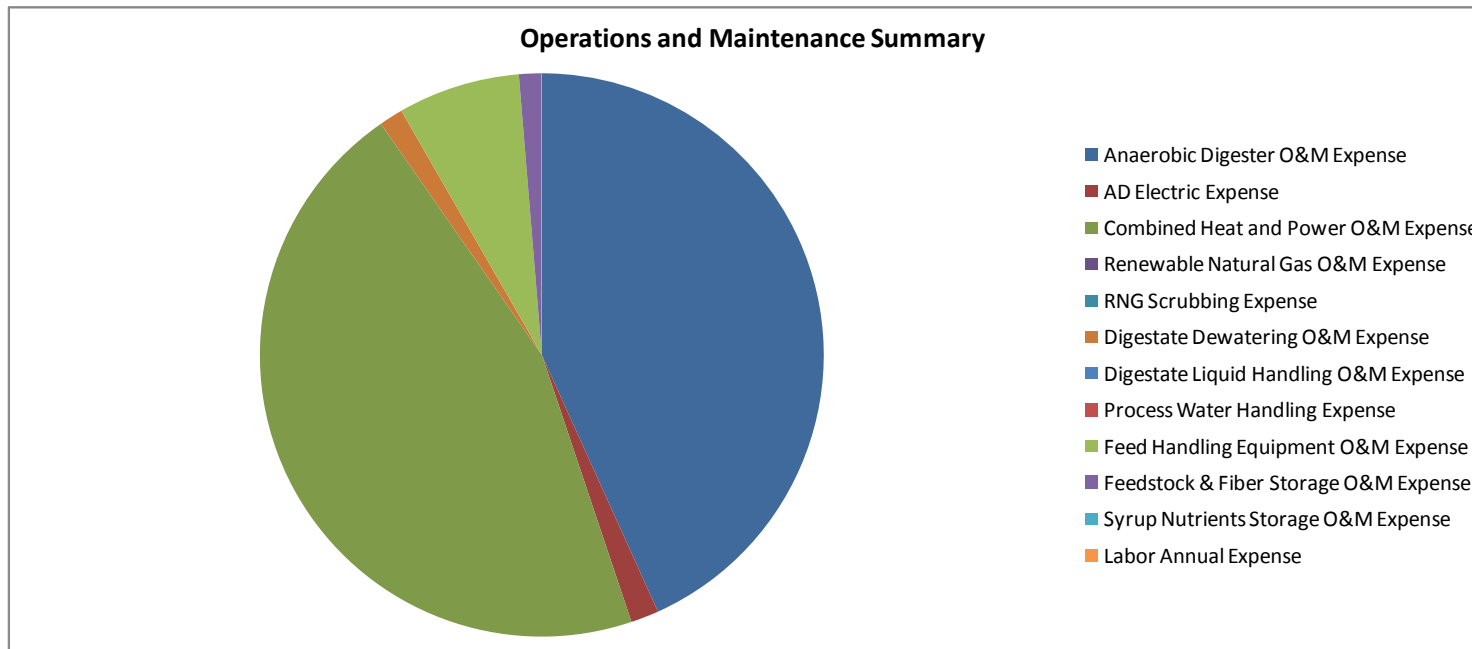
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### Operations and Maintenance Summary Notes

Capital Expenditure Item	Operations and Maintenance Expense	Percent of Total
<a href="#">GoTo</a> Anaerobic Digester O&M Expense	\$ (79,429)	43.2%
<a href="#">GoTo</a> AD Electric Expense	\$ (2,964)	1.6%
<a href="#">GoTo</a> Combined Heat and Power O&M Expense	\$ (83,554)	45.5%
<a href="#">GoTo</a> Renewable Natural Gas O&M Expense	\$ -	0.0%
<a href="#">GoTo</a> RNG Scrubbing Expense	\$ -	0.0%
<a href="#">GoTo</a> Digestate Dewatering O&M Expense	\$ (2,527)	1.4%
<a href="#">GoTo</a> Digestate Liquid Handling O&M Expense	\$ -	0.0%
<a href="#">GoTo</a> Process Water Handling Expense	\$ -	0.0%
<a href="#">GoTo</a> Feed Handling Equipment O&M Expense	\$ (12,872)	7.0%
<a href="#">GoTo</a> Feedstock & Fiber Storage O&M Expense	\$ (2,369)	1.3%
<a href="#">GoTo</a> Syrup Nutrients Storage O&M Expense	\$ -	0.0%
<a href="#">GoTo</a> Labor Annual Expense	\$ -	0.0%
<small>InsZone</small>		
<b>Total Operations and Maintenance Summary</b>	<b>\$ (183,715)</b>	<b>100.0%</b>



## Federal Production Tax Credit or Investment Tax Credit (PTC or ITC)

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### Tax Credit to Use

Tax Credit Choice:

- PTC
- ITC
- ITC Grant
- None

Tax Credit Selected ITC Grant

### Value of the PTC

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	8 2018	9 2019	10 2020
Full Federal Production Tax Credit	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Half Federal Production Tax Credit	\$ -	\$ 55,081	\$ 56,113	\$ 56,829	\$ 57,704	\$ 58,578	\$ 59,620	\$ 60,327	\$ 61,201	\$ 62,075	\$ 63,127
<b>Federal Production Tax Credit</b>	<b>\$ -</b>	<b>\$ 55,081</b>	<b>\$ 56,113</b>	<b>\$ 56,829</b>	<b>\$ 57,704</b>	<b>\$ 58,578</b>	<b>\$ 59,620</b>	<b>\$ 60,327</b>	<b>\$ 61,201</b>	<b>\$ 62,075</b>	<b>\$ 63,127</b>

PTC Net Present Value **\$ 358,755**  
Discount Rate 10.0%

### Value of the ITC

ITC Discount Factor 30%

Investment Item	Capital Expenditure	Percent ITC Eligible	ITC Eligible Value	ITC Value
<a href="#">GoTo</a> Anaerobic Digester CapEx	\$ 3,341,693	98%	\$ 3,274,859	\$ 982,458
<a href="#">GoTo</a> Combined Heat and Power CapEx	\$ 1,088,996	100%	\$ 1,088,996	\$ 326,699
<a href="#">GoTo</a> Renewable Natural Gas CapEx	\$ -	0%	\$ -	\$ -
<a href="#">GoTo</a> Digestate Dewatering CapEx	\$ 106,313	100%	\$ 106,313	\$ 31,894
<a href="#">GoTo</a> Digestate Liquid Handling CapEx	\$ -	0%	\$ -	\$ -
<a href="#">GoTo</a> Feed Handling Equipment CapEx	\$ 541,527	100%	\$ 541,527	\$ 162,458
<a href="#">GoTo</a> Feedstock & Fiber Storage CapEx	\$ 149,500	0%	\$ -	\$ -
<a href="#">GoTo</a> Syrup Nutrients Storage CapEx	\$ -	100%	\$ -	\$ -
<a href="#">GoTo</a> Land CapEx	N/A	N/A	N/A	N/A
<a href="#">GoTo</a> Carbon Offsets Initial Fees	\$ -	0%	\$ -	\$ -
<a href="#">GoTo</a> Green Tags Initial Certification	\$ -	0%	\$ -	\$ -
<a href="#">GoTo</a> Other Project Costs CapEx	\$ 442,000	0%	\$ -	\$ -
InsZone				
<b>Total Investment</b>	<b>\$ 5,670,029</b>		<b>\$ 5,011,695</b>	<b>\$ 1,503,508</b>

### Value of the ITC Grant

Value of the ITC Grant **\$ 1,503,508**

## Oregon Business Energy Tax Credit (BETC)

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### BETC Eligible Costs

Investment Item	Percent BETC Eligible	BETC Value
<a href="#">GoTo</a> Anaerobic Digester CapEx	100%	\$ 3,341,693
<a href="#">GoTo</a> Combined Heat and Power CapEx	100%	\$ 1,088,996
<a href="#">GoTo</a> Renewable Natural Gas CapEx	0%	\$ -
<a href="#">GoTo</a> Digestate Dewatering CapEx	100%	\$ 106,313
<a href="#">GoTo</a> Digestate Liquid Handling CapEx	0%	\$ -
<a href="#">GoTo</a> Feed Handling Equipment CapEx	100%	\$ 541,527
<a href="#">GoTo</a> Feedstock & Fiber Storage CapEx	100%	\$ 149,500
<a href="#">GoTo</a> Syrup Nutrients Storage CapEx	0%	\$ -
<a href="#">GoTo</a> Land CapEx	N/A	N/A
<a href="#">GoTo</a> Carbon Offsets Initial Fees	0%	\$ -
<a href="#">GoTo</a> Green Tags Initial Certification	0%	\$ -
<a href="#">GoTo</a> Other Project Costs CapEx	100%	\$ 442,000
<a href="#">GoTo</a> Total Other Investment Expenses	0%	\$ -
InsZone		
<b>Total Investment</b>		<b>\$ 5,670,029</b>

### Federal Grant Reductions

Federal Grant Reductions \$ 2,003,508

### Total BETC Eligible Costs

**\$ 3,666,520**

### BETC Review Fee

#### BETC Parameters

Review Fee Rate	0.0060
Review Fee Cap	\$ 35,000
Tax Credit Percent	50%
Tax Credit Duration in Years	5
Pass-through Percent	33.5%

#### BETC Review Fee

Eligible Costs	\$ 3,666,520
<b>BETC Review Fee</b>	<b>\$ 21,999</b>

Value is used on the Income Statement

**Retain Vs. Pass-Through Decision**

**Client**

**Tax Rate Parameters**

Federal Effective Tax Rate	32.0%	Value is set on the <b>Client</b> tab.
Oregon Effective Tax Rate	9.0%	Value is set on <b>Parameters</b> tab
<b>Combined Effective Tax Rate</b>	<b>41.0%</b>	

**Percent of BETC to Retain Suggestions**

These suggested percentages are provided if the goal is to retain enough of the BETC to offset the tax implications for selling the BETC. Choose the appropriate percent depending on your offset goals.

Offset Federal Tax Only	17.6548%
Offset Oregon Tax Only	5.6871%
<b>Offset Federal and Oregon Tax</b>	<b>21.5502%</b>

**Percent of BETC to Retain**

To complete retain the tax credit use 100%, to completely sell it use 0%, otherwise enter what percent of the credit to retain.

Percent of BETC to Retain	0.0000%
---------------------------	---------

**Value of BETC Retained**

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015
Percent Full Value of BETC		10%	10%	10%	10%	10%
		\$ 366,652	\$ 366,652	\$ 366,652	\$ 366,652	\$ 366,652
<b>Amount of BETC to Retain</b>		\$ -	\$ -	\$ -	\$ -	\$ -

Values are used on the **Tax Summary** tab

**Value of BETC Pass-through**

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015
Pass-through Percent		33.5%				
Pass-through Value		\$ 1,228,284				
<b>Amount of BETC to Pass-through</b>		\$ 1,228,284				

Value is used on the **Income Statement**

## Depreciation Schedule

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

Confidential and Proprietary!

Nav

### CapEx Depreciable Basis Adjustment

ITC Credit Selected  
Use Adjusted Depreciable Basis

ITC Grant  
Yes

Selection is made on the ITC tab

Capital Expenditure	Original Capital Expenditure	ITC Value	Adjusted Capital Expenditure	Capital Expenditure Value to Use
Anaerobic Digester CapEx	\$ 3,341,693	\$ 982,458	\$ 2,850,464	\$ 2,850,464
Combined Heat and Power CapEx	\$ 1,088,996	\$ 326,699	\$ 925,646	\$ 925,646
Renewable Natural Gas CapEx	\$ -	\$ -	\$ -	\$ -
Digestate Dewatering CapEx	\$ 106,313	\$ 31,894	\$ 90,366	\$ 90,366
Digestate Liquid Handling CapEx	\$ -	\$ -	\$ -	\$ -
Feed Handling Equipment CapEx	\$ 541,527	\$ 162,458	\$ 460,298	\$ 460,298
Feedstock & Fiber Storage CapEx	\$ 149,500	\$ -	\$ 149,500	\$ 149,500
Syrup Nutrients Storage CapEx	\$ -	\$ -	\$ -	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	\$ -	\$ -	\$ -
Green Tags Initial Certification	\$ -	\$ -	\$ -	\$ -
Other Project Costs CapEx	\$ 442,000	\$ -	\$ 442,000	\$ 442,000
<b>Total Capital Expenditures</b>	<b>\$ 5,670,029</b>	<b>\$ 1,503,508</b>	<b>\$ 4,918,274</b>	<b>\$ 4,918,274</b>

### Depreciation Method Selection

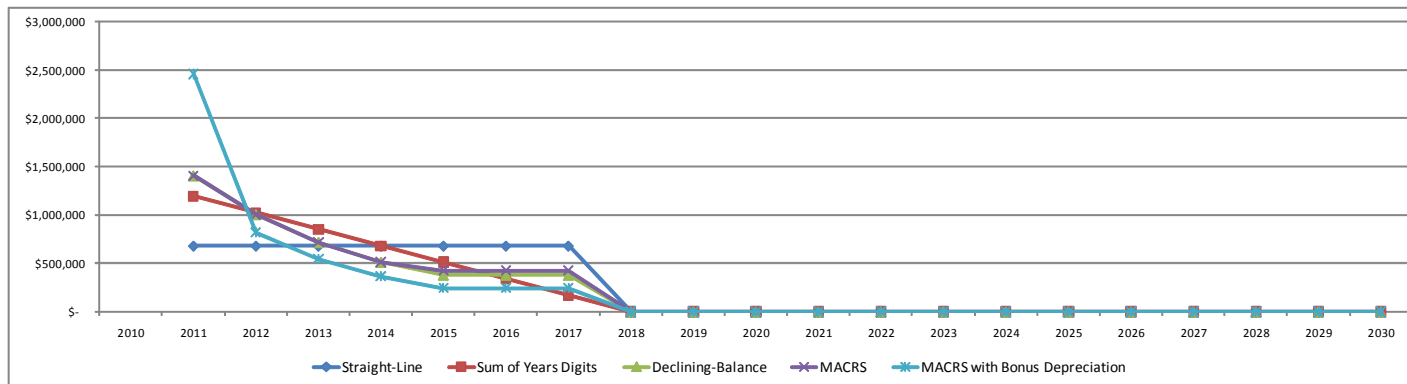
Straight-Line  
Sum of Years Digits  
Declining-Balance  
MACRS

### Depreciation Method Selected

0	1	2	3	4	5	6	7
2010	2011	2012	2013	2014	2015	2016	2017
	\$ 2,459,137	\$ 1,003,729	\$ 716,950	\$ 512,107	\$ 426,756	\$ 426,756	\$ 426,756

These values are used on the Income and Cash Flow tabs

### Depreciation Comparisons



**Depreciation Choices**

**Straight-Line**

Capital Expenditure	Capital Expenditure	Life Span Years	Salvage Value Percent	Salvage Value
Anaerobic Digester CapEx	\$ 2,850,464	7	2.5%	\$ 83,542
Combined Heat and Power CapEx	\$ 925,646	7	2.5%	\$ 27,225
Renewable Natural Gas CapEx	\$ -	-	0.0%	\$ -
Digestate Dewatering CapEx	\$ 90,366	7	2.5%	\$ 2,658
Digestate Liquid Handling CapEx	\$ -	7	2.5%	\$ -
Feed Handling Equipment CapEx	\$ 460,298	7	2.5%	\$ 13,538
Feedstock & Fiber Storage CapEx	\$ 149,500	7	2.5%	\$ 3,738
Syrup Nutrients Storage CapEx	\$ -	-	0.0%	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	-	0.0%	\$ -
Green Tags Initial Certification	\$ -	-	0.0%	\$ -
Other Project Costs CapEx	\$ 442,000	7	2.5%	\$ 11,050
<b>Total Capital Expenditures</b>	<b>\$ 4,918,274</b>			<b>\$ 141,751</b>

0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017
\$ 395,275	\$ 395,275	\$ 395,275	\$ 395,275	\$ 395,275	\$ 395,275	\$ 395,275	\$ 395,275
\$ 128,346	\$ 128,346	\$ 128,346	\$ 128,346	\$ 128,346	\$ 128,346	\$ 128,346	\$ 128,346
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 12,530	\$ 12,530	\$ 12,530	\$ 12,530	\$ 12,530	\$ 12,530	\$ 12,530	\$ 12,530
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 63,823	\$ 63,823	\$ 63,823	\$ 63,823	\$ 63,823	\$ 63,823	\$ 63,823	\$ 63,823
\$ 20,823	\$ 20,823	\$ 20,823	\$ 20,823	\$ 20,823	\$ 20,823	\$ 20,823	\$ 20,823
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 61,564	\$ 61,564	\$ 61,564	\$ 61,564	\$ 61,564	\$ 61,564	\$ 61,564	\$ 61,564
<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>	<b>\$ 682,361</b>

**Sum of Years Digits**

Capital Expenditure	Capital Expenditure	Life Span Years	Salvage Value Percent	Salvage Value
Anaerobic Digester CapEx	\$ 2,850,464	7	2.5%	\$ 83,542
Combined Heat and Power CapEx	\$ 925,646	7	2.5%	\$ 27,225
Renewable Natural Gas CapEx	\$ -	-	0.0%	\$ -
Digestate Dewatering CapEx	\$ 90,366	7	2.5%	\$ 2,658
Digestate Liquid Handling CapEx	\$ -	7	2.5%	\$ -
Feed Handling Equipment CapEx	\$ 460,298	7	2.5%	\$ 13,538
Feedstock & Fiber Storage CapEx	\$ 149,500	7	2.5%	\$ 3,738
Syrup Nutrients Storage CapEx	\$ -	-	0.0%	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	-	0.0%	\$ -
Green Tags Initial Certification	\$ -	-	0.0%	\$ -
Other Project Costs CapEx	\$ 442,000	7	2.5%	\$ 11,050
<b>Total Capital Expenditures</b>	<b>\$ 4,918,274</b>			<b>\$ 141,751</b>

0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017
\$ 691,730	\$ 592,912	\$ 494,093	\$ 395,275	\$ 296,456	\$ 197,637	\$ 88,819	\$ 32,086
\$ 224,605	\$ 192,519	\$ 160,432	\$ 128,346	\$ 96,259	\$ 64,173	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 21,927	\$ 18,795	\$ 15,662	\$ 12,530	\$ 9,397	\$ 6,265	\$ 3,132	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 111,690	\$ 95,734	\$ 79,779	\$ 63,823	\$ 47,867	\$ 31,911	\$ 15,956	\$ -
\$ 36,441	\$ 31,235	\$ 26,029	\$ 20,823	\$ 15,617	\$ 10,412	\$ 5,206	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 107,738	\$ 92,346	\$ 76,955	\$ 61,564	\$ 46,173	\$ 30,782	\$ 15,391	\$ -
<b>\$ 1,194,131</b>	<b>\$ 1,023,541</b>	<b>\$ 852,951</b>	<b>\$ 682,361</b>	<b>\$ 511,770</b>	<b>\$ 341,180</b>	<b>\$ 170,590</b>	<b>\$ -</b>

**Declining-Balance**

Factor    
 A Factor of 2 is used for the double-declining method.

Switch to Straight-Line Depreciation?    
 A value of "Yes" causes the calculation to switch to the straight-line method when depreciation is greater than the declining balance method.

Note: A "No" value may not fully depreciate an asset by the end of its life.

Capital Expenditure	Capital Expenditure	Life Span Years	Salvage Value Percent	Salvage Value
Anaerobic Digester CapEx	\$ 2,850,464	7	2.5%	\$ 83,542
Combined Heat and Power CapEx	\$ 925,646	7	2.5%	\$ 27,225
Renewable Natural Gas CapEx	\$ -	-	0.0%	\$ -
Digestate Dewatering CapEx	\$ 90,366	7	2.5%	\$ 2,658
Digestate Liquid Handling CapEx	\$ -	7	2.5%	\$ -
Feed Handling Equipment CapEx	\$ 460,298	7	2.5%	\$ 13,538
Feedstock & Fiber Storage CapEx	\$ 149,500	7	2.5%	\$ 3,738
Syrup Nutrients Storage CapEx	\$ -	-	0.0%	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	-	0.0%	\$ -
Green Tags Initial Certification	\$ -	-	0.0%	\$ -
Other Project Costs CapEx	\$ 442,000	7	2.5%	\$ 11,050
<b>Total Capital Expenditures</b>	<b>\$ 4,918,274</b>			<b>\$ 141,751</b>

0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017
\$ 814,418	\$ 581,727	\$ 415,520	\$ 296,800	\$ 219,486	\$ 161,819	\$ 121,414	\$ 88,819
\$ 264,470	\$ 188,907	\$ 134,934	\$ 96,381	\$ 71,243	\$ 53,432	\$ 40,074	\$ 30,056
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 25,819	\$ 18,442	\$ 13,173	\$ 9,409	\$ 6,955	\$ 5,227	\$ 3,970	\$ 3,014
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 131,514	\$ 93,938	\$ 67,099	\$ 47,928	\$ 35,427	\$ 26,570	\$ 20,003	\$ 15,002
\$ 42,714	\$ 30,510	\$ 21,793	\$ 15,566	\$ 11,226	\$ 8,419	\$ 6,314	\$ 4,735
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ 126,286	\$ 90,204	\$ 64,431	\$ 46,022	\$ 34,669	\$ 26,002	\$ 19,501	\$ 14,626
<b>\$ 1,405,221</b>	<b>\$ 1,003,729</b>	<b>\$ 716,950</b>	<b>\$ 512,107</b>	<b>\$ 379,505</b>	<b>\$ 283,505</b>	<b>\$ 212,505</b>	<b>\$ 159,505</b>

**MACRS**

Use Bonus Depreciation? Yes  
 Bonus Depreciation Factor 50%

Capital Expenditure	Capital Expenditure	Life Span Years	Salvage Value Percent	Salvage Value
Anaerobic Digester CapEx	\$ 2,850,464	7	0.0%	\$ -
Combined Heat and Power CapEx	\$ 925,646	7	0.0%	\$ -
Renewable Natural Gas CapEx	\$ -	-	0.0%	\$ -
Digestate Dewatering CapEx	\$ 90,366	7	0.0%	\$ -
Digestate Liquid Handling CapEx	\$ -	7	0.0%	\$ -
Feed Handling Equipment CapEx	\$ 460,298	7	0.0%	\$ -
Feedstock & Fiber Storage CapEx	\$ 149,500	7	0.0%	\$ -
Syrup Nutrients Storage CapEx	\$ -	-	0.0%	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	-	0.0%	\$ -
Green Tags Initial Certification	\$ -	-	0.0%	\$ -
Other Project Costs CapEx	\$ 442,000	7	0.0%	\$ -
InsZone				
<b>Total Capital Expenditures</b>	<b>\$ 4,918,274</b>			<b>\$ -</b>

**MACRS with Bonus Depreciation**

Capital Expenditure	Capital Expenditure	Life Span Years	Salvage Value Percent	Salvage Value
Anaerobic Digester CapEx	\$ 2,850,464	7	0.0%	\$ -
Combined Heat and Power CapEx	\$ 925,646	7	0.0%	\$ -
Renewable Natural Gas CapEx	\$ -	-	0.0%	\$ -
Digestate Dewatering CapEx	\$ 90,366	7	0.0%	\$ -
Digestate Liquid Handling CapEx	\$ -	7	0.0%	\$ -
Feed Handling Equipment CapEx	\$ 460,298	7	0.0%	\$ -
Feedstock & Fiber Storage CapEx	\$ 149,500	7	0.0%	\$ -
Syrup Nutrients Storage CapEx	\$ -	-	0.0%	\$ -
Land CapEx	N/A	N/A	N/A	N/A
Carbon Offsets Initial Fees	\$ -	-	0.0%	\$ -
Green Tags Initial Certification	\$ -	-	0.0%	\$ -
Other Project Costs CapEx	\$ 442,000	7	0.0%	\$ -
InsZone				
<b>Total Capital Expenditures</b>	<b>\$ 4,918,274</b>			<b>\$ -</b>

0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017
\$ -	\$ 814,418	\$ 581,727	\$ 415,520	\$ 296,800	\$ 247,333	\$ 247,333	\$ 247,333
\$ -	\$ 264,470	\$ 188,907	\$ 134,934	\$ 96,381	\$ 80,318	\$ 80,318	\$ 80,318
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 25,819	\$ 18,442	\$ 13,173	\$ 9,409	\$ 7,841	\$ 7,841	\$ 7,841
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 131,514	\$ 93,938	\$ 67,099	\$ 47,928	\$ 39,940	\$ 39,940	\$ 39,940
\$ -	\$ 42,714	\$ 30,510	\$ 21,793	\$ 15,566	\$ 12,972	\$ 12,972	\$ 12,972
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 126,286	\$ 90,204	\$ 64,431	\$ 46,022	\$ 38,352	\$ 38,352	\$ 38,352
\$ -	\$ 1,405,221	\$ 1,003,729	\$ 716,950	\$ 512,107	\$ 426,756	\$ 426,756	\$ 426,756

0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017
\$ -	\$ 1,425,232	\$ 475,077	\$ 316,718	\$ 211,145	\$ 140,764	\$ 140,764	\$ 140,764
\$ -	\$ 462,823	\$ 154,274	\$ 102,850	\$ 68,566	\$ 45,711	\$ 45,711	\$ 45,711
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 45,183	\$ 15,061	\$ 10,041	\$ 6,694	\$ 4,463	\$ 4,463	\$ 4,463
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 230,149	\$ 76,716	\$ 51,144	\$ 34,096	\$ 22,731	\$ 22,731	\$ 22,731
\$ -	\$ 74,750	\$ 24,917	\$ 16,611	\$ 11,074	\$ 7,383	\$ 7,383	\$ 7,383
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
\$ -	\$ 221,000	\$ 73,667	\$ 49,111	\$ 32,741	\$ 21,827	\$ 21,827	\$ 21,827
\$ -	\$ 2,459,137	\$ 819,712	\$ 546,475	\$ 364,317	\$ 242,878	\$ 242,878	\$ 242,878

## Tax Credit Summary

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

Confidential and Proprietary!

Nav

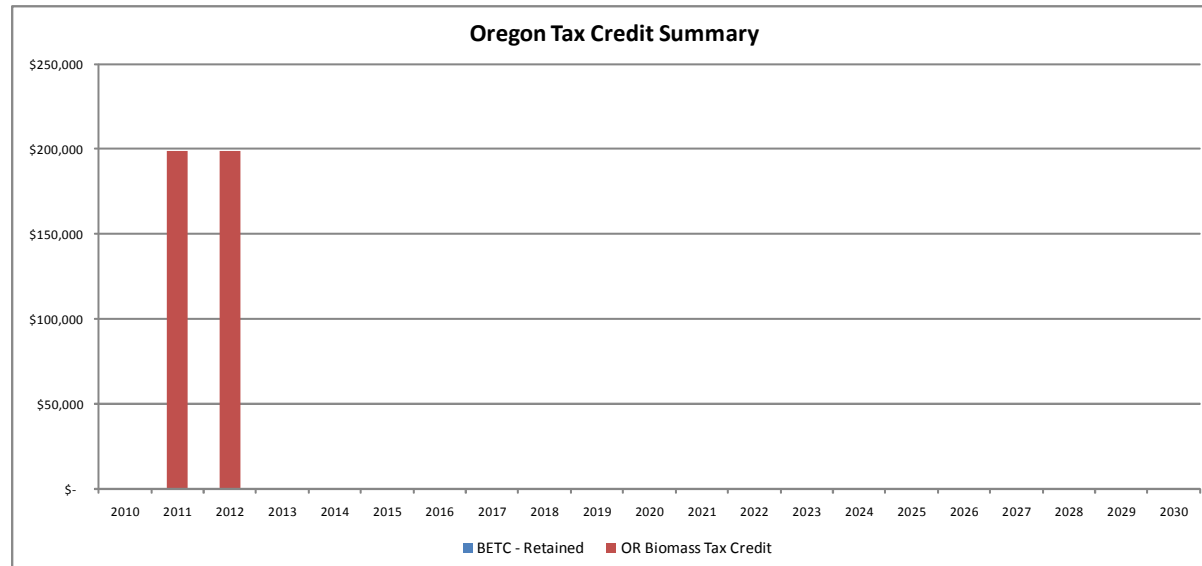
### Oregon Tax Credit Summary

GoTo

GoTo

InsZone

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	8 2018	9 2019	10 2020	11 2021	12 2022	13 2023
BETC - Retained	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OR Biomass Tax Credit	\$ -	\$ 198,850	\$ 198,850	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Total Oregon Tax Credits</b>	<b>\$ -</b>	<b>\$ 198,850</b>	<b>\$ 198,850</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>



## Funding

### EC Oregon - AD Financial Feasibility Model v2.3

#### Jerry Noble - Base Case

Confidential and Proprietary!

Nav

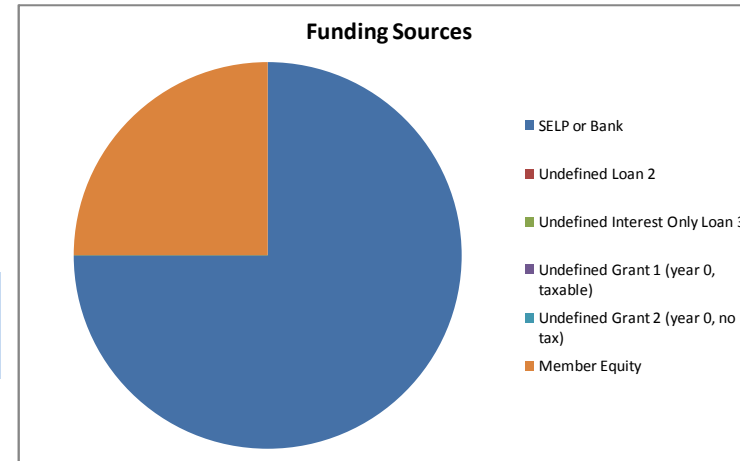
#### Total Investment

Investment Item	Cost
Anaerobic Digester CapEx	\$ 3,341,693
Combined Heat and Power CapEx	\$ 1,088,996
Renewable Natural Gas CapEx	\$ -
Digestate Dewatering CapEx	\$ 106,313
Digestate Liquid Handling CapEx	\$ -
Feed Handling Equipment CapEx	\$ 541,527
Feedstock & Fiber Storage CapEx	\$ 149,500
Syrup Nutrients Storage CapEx	\$ -
Land CapEx	\$ -
Carbon Offsets Initial Fees	\$ -
Green Tags Initial Certification	\$ -
Other Project Costs CapEx	\$ 442,000
Total Other Investment Expenses	\$ -
Ins.Zone	
<b>Total Investment</b>	<b>\$ 5,670,029</b>

#### Funding Sources

##### Funding Parameters

Percent Debt Financing via Loan 1	75%	\$ 4,252,521	SELP or Bank
Percent Debt Financing via Loan 2	0%	\$ -	Undefined Loan 2
Percent Debt Financing via Interest Only Loan 3	0%	\$ -	Undefined Interest Only Loan 3
Percent Grant 1 (year 0, taxable)	0%	\$ -	Undefined Grant 1 (year 0, taxable)
Percent Grant 2 (year 0, non-taxable)	0%	\$ -	Undefined Grant 2 (year 0, no tax)
Percent Equity	25%	\$ 1,417,507	Member Equity
Ins.Zone			
<b>Total Funding</b>	<b>100%</b>	<b>\$ 5,670,029</b>	
<b>Debt to Equity Ratio</b>		<b>4.00</b>	



**Debt Financing - SELP or Bank**

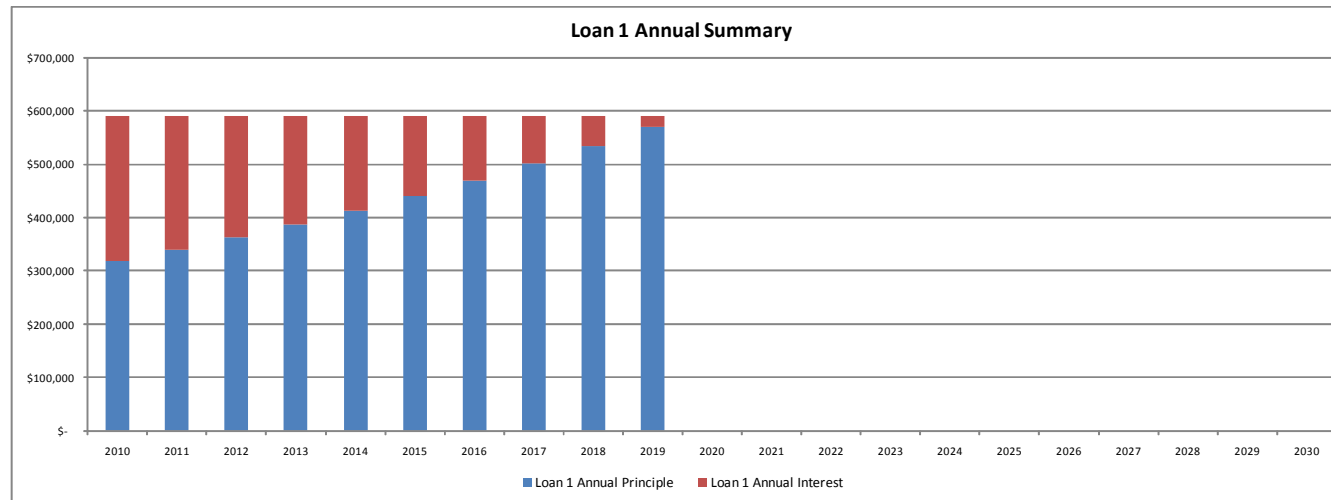
Loan 1 Parameters

Loan Type	Amortization Loan
Loan Amount	\$ 4,252,521
Annual Interest Rate	6.50%
Loan Points	2.00%
Number of Years	10
Loan Start Year	2010
Points	\$ 85,050
Loan Amount with Points	\$ 4,337,572



**SELP or Bank Annual Summary**

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	8 2018	9 2019
Loan 1 Starting Balance	\$ 4,337,572									
Loan 1 Annual Principle	\$ 318,461	\$ 339,789	\$ 362,546	\$ 386,826	\$ 412,732	\$ 440,374	\$ 469,866	\$ 501,334	\$ 534,910	\$ 570,733
Loan 1 Annual Interest	\$ 272,566	\$ 251,238	\$ 228,481	\$ 204,201	\$ 178,295	\$ 150,653	\$ 121,161	\$ 89,693	\$ 56,117	\$ 20,294
Loan 1 Annual Payment	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027	\$ 591,027
Loan 1 End of Year Balance	\$ 4,019,111	\$ 3,679,321	\$ 3,316,776	\$ 2,929,950	\$ 2,517,217	\$ 2,076,844	\$ 1,606,977	\$ 1,105,643	\$ 570,733	\$ (0)



## Round 2 Funding (Delayed)

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

Confidential and Proprietary!

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### Additional Funding Sources

Funding Source Type	Amount	Funding Source Name	Reduces BETC?	BETC Reduction
	US \$		Yes / No	US \$
Grant 3 (year 1, taxable)	\$ 500,000	USDA REAP Grant (year 1, taxable)	Yes	\$ 500,000
Grant 4 (year 1, non-taxable)	\$ -	Undefined Grant 4 (year 1, no tax)	No	\$ -
ITC Grant (year 1, non-taxable)	\$ 1,503,508	ITC Grant (year 1, no tax)	Yes	\$ 1,503,508
<b>Total Additional Funding</b>	<b>\$ 2,003,508</b>			<b>\$ 2,003,508</b>

InsZone





## Projected Income Statement

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

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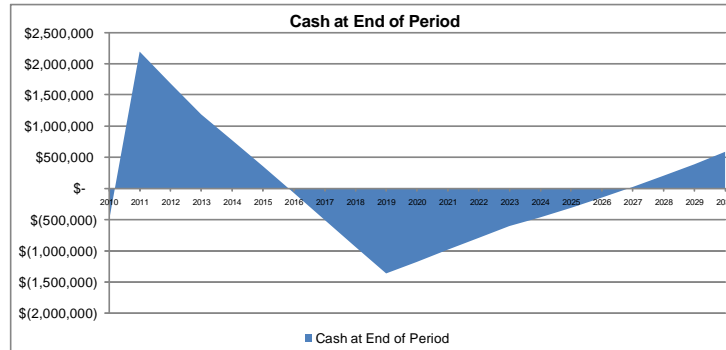
	Inflation Rate	What If?	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	8 2018	20 2030
<b>Tax Credits Available</b>												
<b>Federal Tax Credits Available</b>												
GoTo		Full Federal Production Tax Credit	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
GoTo		Half Federal Production Tax Credit	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
GoTo		Investment Tax Credit	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone		<b>Total Federal Tax Credits Available</b>	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Oregon Tax Credits Available</b>												
GoTo		BETC - Retained	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
GoTo		OR Biomass Tax Credit	\$ -	\$ 198,850	\$ 198,850	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone		<b>Total Oregon Tax Credits Available</b>	\$ -	\$ 198,850	\$ 198,850	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone		<b>Total Tax Credits Available</b>	\$ -	\$ 198,850	\$ 198,850	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>Projected Pass-Through LLC Income Tax Liability (FYI Purposes Only)</b>												
		taxable Pre-Tax Income / (Loss)	\$ (294,565)	\$ (907,868)	\$ (1,144,358)	\$ (832,512)	\$ (511,491)	\$ (401,574)	\$ (383,229)	\$ (359,132)	\$ 101,124	\$ 199,354
<b>Projected Federal Tax</b>												
Client		Effective Federal Tax Rate										
		Federal Tax	32.0%									
		<i>If income is less than zero then the Federal Tax is set to zero</i>	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ (32,360)	\$ (63,793)
		Federal Tax Credits Available	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone		<b>Total Projected Federal Tax</b>	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ (32,360)	\$ (63,793)
		<i>If there is no tax liability, any positive balance is zeroed out</i>										
<b>Projected Oregon Tax</b>												
Client		Effective Oregon Tax Rate										
		Oregon Tax	9.0%									
		<i>If income is less than zero then the Oregon Tax is set to zero</i>	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ (9,101)	\$ (17,942)
		Oregon Tax Credits Available	\$ -	\$ 198,850	\$ 198,850	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone		<b>Total Projected Oregon Tax</b>	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ (9,101)	\$ (17,942)
		<i>If there is no tax liability, any positive balance is zeroed out</i>										
InsZone		<b>Post-Tax Income / (Loss)</b>	\$ (294,565)	\$ 595,641	\$ (1,144,358)	\$ (832,512)	\$ (511,491)	\$ (401,574)	\$ (383,229)	\$ (359,132)	\$ 59,663	\$ 117,619
		Post-Tax Return on Investment (ROI)	21+									
		Post-Tax Return on Investment Percent	-5.2%	53.9%	-2.5%	-2.0%	0.0%	0.4%	0.8%	1.2%	1.1%	2.1%
		Post-Tax Return on Equity (ROE)	1.56									
		Post-Tax Return on Equity Percent	-20.8%	215.5%	-9.9%	-8.2%	0.0%	1.8%	3.1%	4.8%	4.2%	8.3%

**Projected Cash Flow Statement**

EC Oregon - AD Financial Feasibility Model v2.3  
 Jerry Noble - Base Case  
 Confidential and Proprietary

2010

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Pre-Tax Income / (Loss)	\$ (294,565)	\$ 595,641	\$ (1,144,359)	\$ (832,512)	\$ (511,491)	\$ (401,574)	\$ (383,229)	\$ (359,132)	\$ 101,124	\$ 146,533	\$ 180,839	\$ 194,795	\$ 190,162	\$ 189,329	\$ 142,010	\$ 150,317	\$ 167,478	\$ 167,211	\$ 179,232	\$ 184,984	\$ 199,354	
Operating Activities																						
MACRS Depreciation	\$ -	\$ 2,459,137	\$ 1,003,729	\$ 716,950	\$ 512,107	\$ 426,756	\$ 426,756	\$ 426,756	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Net Cash Flow from Operations	\$ (294,565)	\$ 3,054,778	\$ (140,629)	\$ (115,562)	\$ 616	\$ 25,182	\$ 43,526	\$ 67,624	\$ 101,124	\$ 146,533	\$ 180,839	\$ 194,795	\$ 190,162	\$ 189,329	\$ 142,010	\$ 150,317	\$ 167,478	\$ 167,211	\$ 179,232	\$ 184,984	\$ 199,354	
Investing Activities																						
Capital Expenditures	\$ (5,670,029)																					
Member Equity	\$ 1,417,507																					
Member Minimum Distribution for Tax Liability	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Member Profit Distribution	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Net Cash Flow from Investing	\$ (4,252,521)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Financing Activities																						
SELP or Bank	\$ 4,337,572																					
Undefined Loan 2	\$ -																					
Undefined Interest Only Loan 3	\$ -																					
SELP or Bank Principle Repayment	\$ (318,461)	\$ (339,789)	\$ (362,546)	\$ (386,826)	\$ (412,732)	\$ (440,374)	\$ (469,866)	\$ (501,334)	\$ (534,910)	\$ (570,733)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Undefined Loan 2 Principle Repayment	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Undefined Interest Only Loan 3 Principle Repayment	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Net Cash Flow from Financing	\$ 4,019,111	\$ (339,789)	\$ (362,546)	\$ (386,826)	\$ (412,732)	\$ (440,374)	\$ (469,866)	\$ (501,334)	\$ (534,910)	\$ (570,733)	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Net Increase / (Decrease) in Cash and Cash Equivalents	\$ (527,976)	\$ 2,714,989	\$ (503,174)	\$ (502,388)	\$ (412,116)	\$ (415,192)	\$ (426,340)	\$ (433,710)	\$ (433,785)	\$ (424,201)	\$ 180,839	\$ 194,795	\$ 190,162	\$ 189,329	\$ 142,010	\$ 150,317	\$ 167,478	\$ 167,211	\$ 179,232	\$ 184,984	\$ 199,354	
Cash at Beginning of Period	\$ -	\$ (527,976)	\$ 2,187,013	\$ 1,683,839	\$ 1,181,450	\$ 769,334	\$ 354,142	\$ (72,198)	\$ (505,908)	\$ (939,694)	\$ (1,363,894)	\$ (1,183,056)	\$ (988,261)	\$ (798,098)	\$ (608,769)	\$ (466,760)	\$ (316,443)	\$ (148,966)	\$ 18,245	\$ 197,477	\$ 382,461	
Cash at End of Period	\$ (527,976)	\$ 2,187,013	\$ 1,683,839	\$ 1,181,450	\$ 769,334	\$ 354,142	\$ (72,198)	\$ (505,908)	\$ (939,694)	\$ (1,363,894)	\$ (1,183,056)	\$ (988,261)	\$ (798,098)	\$ (608,769)	\$ (466,760)	\$ (316,443)	\$ (148,966)	\$ 18,245	\$ 197,477	\$ 382,461	\$ 581,815	
Net Present Value (NPV)	\$ (622,621)																					
Discount Rate	5.0%																					
Internal Rate of Return (IRR)	1.9%																					
Guess	11.00%																					



## Projected Balance Sheet

EC Oregon - AD Financial Feasibility Model v2.3

Jerry Noble - Base Case

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Nov

	0 2010	1 2011	2 2012	3 2013	4 2014	5 2015	6 2016	7 2017	20 2030
<b>Assets</b>									
<b>Current Assets</b>									
Cash and Cash Equivalents	\$ (527,976)	\$ 2,187,013	\$ 1,683,839	\$ 1,181,450	\$ 769,334	\$ 354,142	\$ (72,198)	\$ (505,908)	\$ 581,815
InsZone									
<b>Total Current Assets</b>	<b>\$ (527,976)</b>	<b>\$ 2,187,013</b>	<b>\$ 1,683,839</b>	<b>\$ 1,181,450</b>	<b>\$ 769,334</b>	<b>\$ 354,142</b>	<b>\$ (72,198)</b>	<b>\$ (505,908)</b>	<b>\$ 581,815</b>
<b>Fixed Assets</b>									
Original Capital Expenditure Value	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029	\$ 5,670,029
MACRS Depreciation	\$ -	\$ 2,459,137	\$ 1,003,729	\$ 716,950	\$ 512,107	\$ 426,756	\$ 426,756	\$ 426,756	\$ -
Accumulated Depreciation	\$ -	\$ 2,459,137	\$ 3,462,867	\$ 4,179,816	\$ 4,691,923	\$ 5,118,679	\$ 5,545,435	\$ 5,972,190	\$ 5,972,190
InsZone									
<b>Total Fixed Assets</b>	<b>\$ 5,670,029</b>	<b>\$ 3,210,891</b>	<b>\$ 2,207,162</b>	<b>\$ 1,490,212</b>	<b>\$ 978,105</b>	<b>\$ 551,350</b>	<b>\$ 124,594</b>	<b>\$ (302,162)</b>	<b>\$ (302,162)</b>
InsZone									
<b>Total Assets</b>	<b>\$ 5,142,053</b>	<b>\$ 5,397,904</b>	<b>\$ 3,891,001</b>	<b>\$ 2,671,663</b>	<b>\$ 1,747,440</b>	<b>\$ 905,492</b>	<b>\$ 52,396</b>	<b>\$ (808,070)</b>	<b>\$ 279,653</b>
<b>Liabilities and Equity</b>									
<b>Long Term Liabilities</b>									
SELP or Bank Principle Balance	\$ 4,019,111	\$ 3,679,321	\$ 3,316,776	\$ 2,929,950	\$ 2,517,217	\$ 2,076,844	\$ 1,606,977	\$ 1,105,643	\$ -
Undefined Loan 2 Principle Balance	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Undefined Interest Only Loan 3 Principle Balance	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
InsZone									
<b>Total Long Term Liabilities</b>	<b>\$ 4,019,111</b>	<b>\$ 3,679,321</b>	<b>\$ 3,316,776</b>	<b>\$ 2,929,950</b>	<b>\$ 2,517,217</b>	<b>\$ 2,076,844</b>	<b>\$ 1,606,977</b>	<b>\$ 1,105,643</b>	<b>\$ -</b>
<b>Equity</b>									
Members Equity	\$ 1,122,942	\$ 1,718,583	\$ 574,225	\$ (258,287)	\$ (769,778)	\$ (1,171,352)	\$ (1,554,581)	\$ (1,913,713)	\$ 279,653
InsZone									
<b>Total Equity</b>	<b>\$ 1,122,942</b>	<b>\$ 1,718,583</b>	<b>\$ 574,225</b>	<b>\$ (258,287)</b>	<b>\$ (769,778)</b>	<b>\$ (1,171,352)</b>	<b>\$ (1,554,581)</b>	<b>\$ (1,913,713)</b>	<b>\$ 279,653</b>
InsZone									
<b>Total Liabilities and Equity</b>	<b>\$ 5,142,053</b>	<b>\$ 5,397,904</b>	<b>\$ 3,891,001</b>	<b>\$ 2,671,663</b>	<b>\$ 1,747,440</b>	<b>\$ 905,492</b>	<b>\$ 52,396</b>	<b>\$ (808,070)</b>	<b>\$ 279,653</b>
InsZone									
<i>Assets = Liabilities and Equity Checksum</i>	\$ -	\$ -	\$ -	\$ -	\$ (0)	\$ (0)	\$ (0)	\$ (0)	\$ (0)

## Summary Stats

### EC Oregon - AD Financial Feasibility Model v2.3

#### Jerry Noble - Base Case

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Nav

#### Investment Dollars

Total Investment Cost	\$	5,670,029
Estimated Net CHP Capacity		616
<b>Investment Dollars / kW</b>	<b>\$</b>	<b>9,209</b>

Total Investment Cost	\$	5,670,029
Herd Size		1,120
<b>Investment Dollars / Animal</b>	<b>\$</b>	<b>5,063</b>

#### Revenue, Expenses and Net Income

Year 1 Baseline Revenue & Opportunity Costs	\$	356,211
Feedstock Wet Tons / Year Utilized		49,403
<b>Revenue / Wet Ton</b>	<b>\$</b>	<b>7.21</b>

Year 1 Baseline Revenue & Opportunity Costs	\$	356,211
CHP Operating Hours / Year		8,520
<b>Revenue / Operating Hour</b>	<b>\$</b>	<b>41.81</b>

Year 1 Baseline Expenses	\$	(281,988)
Feedstock Wet Tons / Year Utilized		49,403
<b>Expenses / Wet Ton</b>	<b>\$</b>	<b>(5.71)</b>

Year 1 Baseline Expenses	\$	(281,988)
CHP Operating Hours / Year		8,520
<b>Expenses / Operating Hour</b>	<b>\$</b>	<b>(33.10)</b>

Year 1 Baseline Net Income	\$	74,223
Feedstock Wet Tons / Year Utilized		49,403
<b>Net Income / Wet Ton</b>	<b>\$</b>	<b>1.50</b>

Year 1 Baseline Net Income	\$	74,223
CHP Operating Hours / Year		8,520
<b>Net Income / Operating Hour</b>	<b>\$</b>	<b>8.71</b>

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## Glossary

ACDP	- Air Contaminant Discharge Permit
ACP	- Anaerobic Contact Process
AD	- Anaerobic Digestion
AGF	- Anoxic Gas Flotation
ARS	- Annual Ryegrass Straw
AWM	- Animal Waste Management (Oregon)
BETC	- Oregon Business Energy Tax Credit
BMP	- Biochemical Methane Potential
BOD	- Biological Oxygen Demand
BSE	- Bovine Spongiform Encephalopathy
Btu	- British Thermal Unit
C:N	- Carbon to Nitrogen ratio
CBM	- Compressed Biomethane
CH <sub>4</sub>	- Methane
CHP	- Combined Heat and Power
CNG	- Compressed Natural Gas
CO <sub>2</sub>	- Carbon Dioxide
COD	- Chemical Oxygen Demand
CSTR	- Continuous Stirred Tank Reactor
DEQ	- Oregon Department of Environmental Quality
DWW	- Water Scrubbing Under Pressure
ESCP	- Erosion and Sediment Control Plan
EU	- European Union
FOG	- Fats, Oils and Grease
g	- gram
g/kg	- gram per kilogram
gpm	- gallons per minute
GTW	- Grease Trap Waste
H <sub>2</sub> O	- Water
H <sub>2</sub> S	- Hydrogen Sulfide
HRT	- Hydraulic Retention Time
IBR	- Induced Blanket Reactor
IC <sub>50</sub>	- Inhibitory Concentrations equivalent to 50% decrease in methane production rate
IRR	- Internal rate of return
kg	- kilogram
kW	- kilowatt
kWh	- kilowatt hour
L	- Liter
LBM	- Liquefied Biomethane
LUCS	- Land Use Compatibility Statement
MC	- Moisture Content
Mcf	- thousand cubic feet
MFW	- Municipal Food Waste
mg/L	- milligram per liter
MMbtu	- Million Btu

MW	- Mega Watt
MWh	- Mega Watt hour
NLCD	- National Land Coverage Data
NPDES	- National Pollution Discharge Elimination
NRCS	- National Resources Conservation Service
O&M	- Operations and Maintenance
OLR	- Organic Loading Rate
pH	- Measure of acidity or alkalinity
PL	- Poultry Litter
ppm	- parts per million
PSA	- Pressure Swing Absorption
PTC	- Renewable Electricity Production Tax Credit
REAP	- Rural Energy for America Program
REC	- Renewable Energy Certificates
RFI	- Request for Information
RNG	- Renewable Natural Gas
RO	- Reverse Osmosis
ROE	- Return on Equity
ROI	- Return on Investment
SBR	- Sequencing Batch Reactor
scf	- standard cubic feet
SELP	- Small Scale Energy Loan Program
SIC	- Standard Industrial Classification
SRM	- Specified Risk Material
SRT	- Solids Residence Time
Ton	- (U.S) 2,000 pounds
tonne	- metric ton
tpd	- tons/day
tpy	- tons/year
TRCs	- Tradable Renewable Certificates
TS	- Total Solids
UASB	- Upflow Anaerobic Sludge Blanket
UF	- Ultrafiltration
USD	- United States dollar
USDA	- United States Department of Agriculture
USGS	- U.S. Geological Survey
VAPG	- Value Added Producer Grant
VER	- Verifiable Emission Reductions
VS	- Volatile Solids
WPCF	- Water Pollution Control Facility